Operator's Manual
DIAMOND™ K-300 Laser Performance Package

COHERENT
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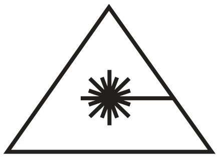
Preface

This manual provides operating and maintenance instructions for the Diamond Model K-300 laser, Performance Package version. It is recommended that the user read Chapter Two, Laser Safety, before operating the laser.



Caution — use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

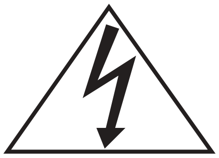
U.S. Export Control Laws Compliance

It is the policy of Coherent to comply strictly with the U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to the U.S. Export Administration Regulations administered by the Department of Commerce, Bureau of Export Administration.

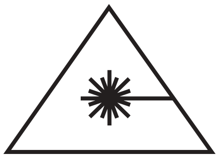
The applicable restrictions vary depending on the specific product involved, intended application, and the product destination. In some cases, an individual validated export license is required from the U.S. Department of Commerce prior to resale or re-export of certain products. If you are uncertain about the obligations imposed by U.S. law, obtain clarification from Coherent.

Symbols Used in This Manual and on the Laser System



This symbol is intended to alert the operator to the presence of dangerous voltages associated with the laser that may be of sufficient magnitude to constitute a risk of electric shock.

This symbol is intended to alert the operator to the presence of important operating and maintenance instructions.

	**This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.**
3~	**3 PHASE ALTERNATING CURRENT.**
~	**ALTERNATING CURRENT.**
⎓	**DIRECT CURRENT.**
⏚	**PROTECTIVE CONDUCTOR TERMINAL.**
⏻	**STANDBY.**
⭘	**OFF OR STOP.**
⏽	**ON OR START.**

OPERATOR'S MANUAL

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CHAPTER ONE
DESCRIPTION AND SPECIFICATIONS

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Introduction and Description

The Diamond laser series is a modular, RF excited, sealed industrial CO_2 pulsed laser. The Diamond K-300 Performance Package (Figure 1-1) consists of a laser head, a power module, a remote control unit and interconnection cables. The power module which can interface with an external controller contains:

- RF amplifier
- DC power supply
- Diamond digital interface (DDI) board
- Internal heat exchanger

See Chapter Six and Chapter Seven for description of the K-300 Basic Plus system. These chapters cover specific installation issues for this model. The specifications for this unit are identical to the K-300 Performance Package.

The Diamond K-300 Performance Package can be operated with nominal input voltages of either 208 VAC or 380 VAC. Refer to Chapter Three for procedures on changing the input voltage to the power module.

The Diamond K-300 has a 80 cm resonator with a 300 Watt average output power level. Specifications are listed in Table 1-3. The Diamond can operate in many pulse formats which allows user control of the output beam and power output. Pulse width and pulse period can be controlled by the remote control unit, by an optional pulse generator connected to the remote control unit, or by an optional external controller as shown on the simplified laser system block diagram, Figure 1-2.

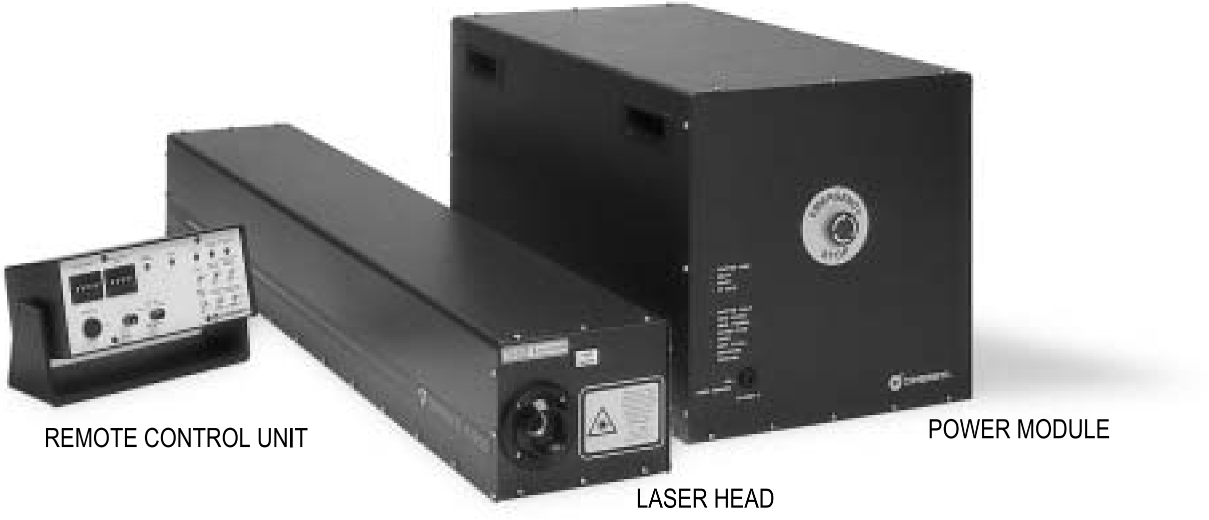


Figure 1-1. Diamond K-300 Laser, Performance Package Version

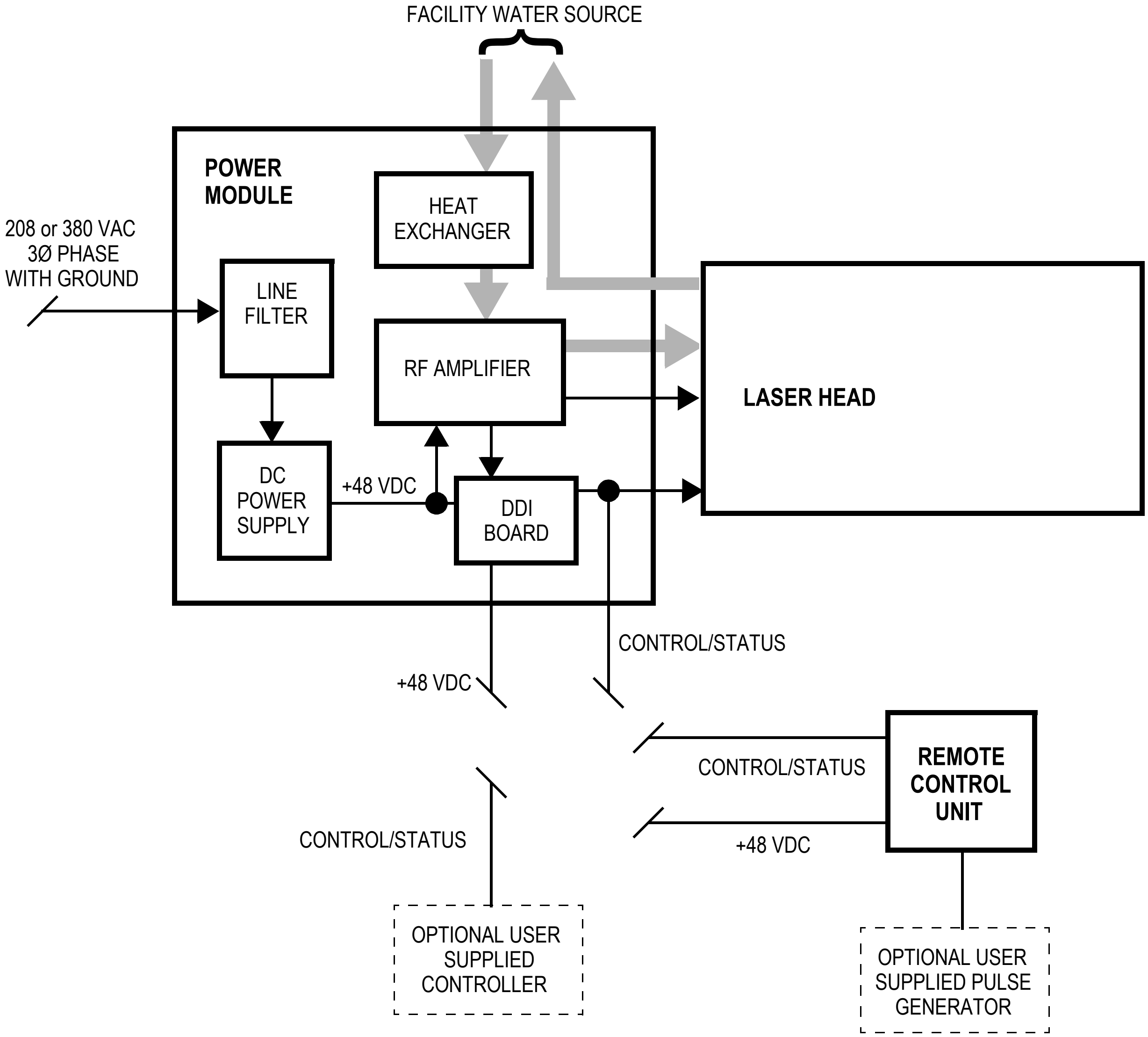


Figure 1-2. Simplified System Block Diagram

Laser Output Control

The methods for controlling the laser output are summarized in the following paragraphs.

Output Control Using the Remote Control Unit

The remote control unit can be used in standard pulse situations and allows immediate use of the laser. More complex pulses can be generated when an optional user supplied pulse generator is connected to the remote control unit. Operation in this manner is discussed in Chapter Four, Daily Operation. The remote control unit has the following features:

- Keyswitch On/Off control (used in conjunction with the power module keyswitch).
- Capability to monitor modulation input to RF amplifier. The RF amplifier is located in the power module.
- Shutter open/closed control (electrically actuated from the remote control unit).
- Aiming beam On/Off control.
- Remote system status monitoring.
- Continuous and momentary modulation control.
- Pulse period and pulse width control (manual and external).
- External safety interlock.
- Remote shutter and modulation control.
- Accepts input from an external pulse generator.

Output Control Using a User Supplied Controller

The DDI interface allows for a wide range of inputs from various controllers resident in machine tools. Inputs are optically isolated. Refer to Appendix A for additional information on interfacing a controller to the Diamond.

Laser Head

The water cooled laser head contains the laser tube, laser head board, an RF matching network, optics, a water flow switch, an emission indicator, and a shutter assembly (Figure 1-3). The shutter assembly contains a water cooled beam energy dissipater, and a diode aiming laser.

The laser head is sealed and requires no external gas for tube operation. Since the head is allowed to breath to account for changes in ambient temperature and pressure, it is equipped with a fitting for a nitrogen purge to avoid contamination of the optics in the shutter assembly. Many laser-based processes require a processing gas in the active work area.

The all metal construction of the laser head provides high thermal stability and resistance to damage due to shock and/or vibration.

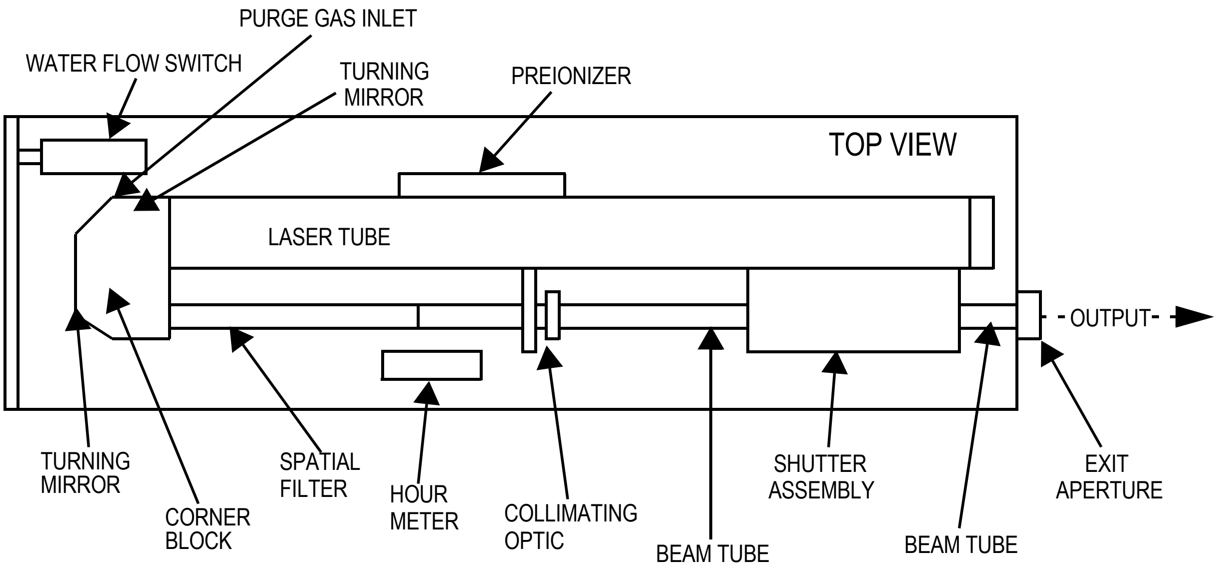


Figure 1-3. Laser Head

Tube

The laser tube consists of a two mirror optical cavity with water cooled rectangular shaped (slab design) aluminum electrodes extending the length of the tube. Coils are positioned as shown on Figure 1-4 to create a uniform distribution of RF energy.

One of the 100% reflecting spherical end mirrors does not extend across the full width of the electrode. This forms the output path for the laser beam. The beam passes through a zinc selenide window at the output end of the tube.

Laser Head Board

The laser head board performs the following functions:

- Monitors sensors in the laser head and routes sensor information to the DDI board. The sensors include the shutter assembly thermal switch, water flow rate and direction, shutter position, and the cover interlock.
- Sends aiming beam on/off signals to the diode aiming beam laser in the shutter assembly.
- Provides the appropriate voltage levels to open and close the shutter.

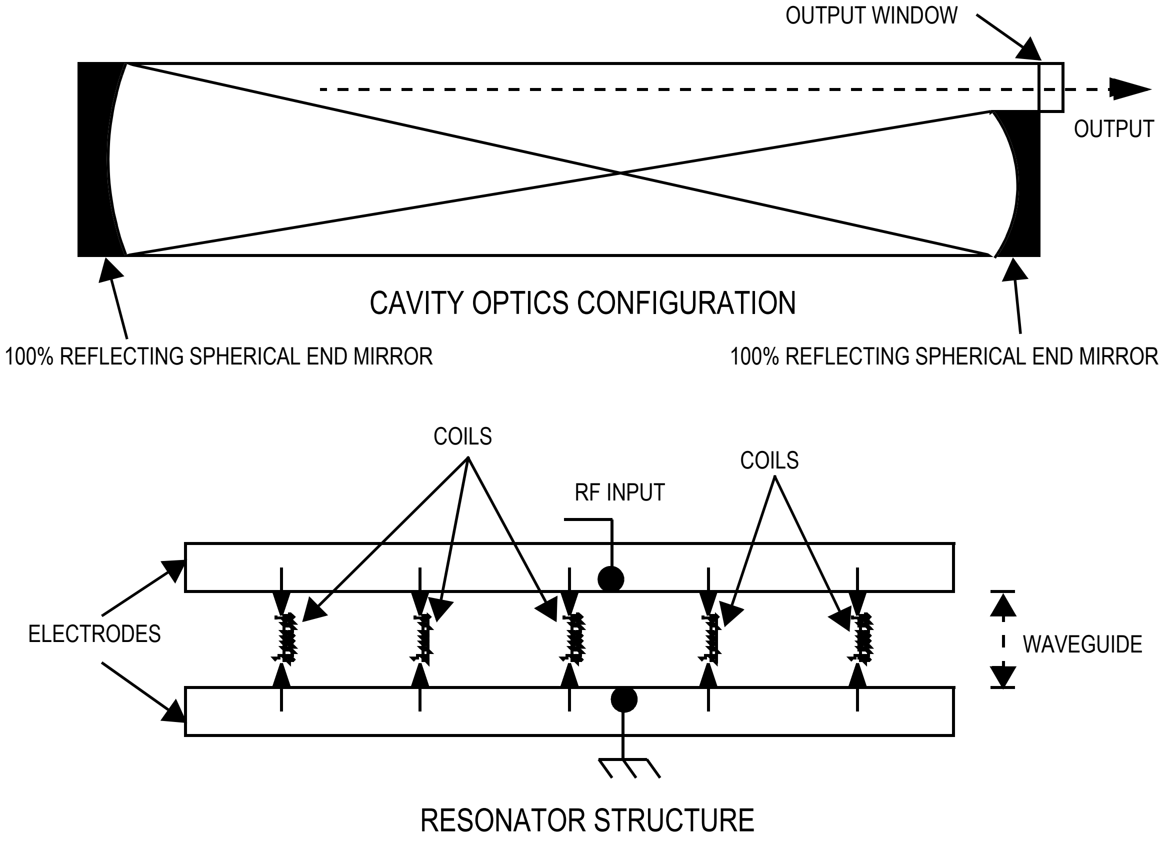

OUTPUT WINDOW
OUTPUT
CAVITY OPTICS CONFIGURATION
100% REFLECTING SPHERICAL END MIRROR
100% REFLECTING SPHERICAL END MIRROR
COILS
RF INPUT
COILS
ELECTRODES
WAVEGUIDE
RESONATOR STRUCTURE

Figure 1-4. Laser Tube

Pre-ionizer

The pre-ionizer initiates a discharge in the tube gas for rapid tube starting after periods of being turned off. The pre-ionizer is on continuously to ensure instant-on operation. The pre-ionizer power source is an RF power supply mounted on the side of the tube.

Optics

The optics are within the sealed head and require no maintenance or alignment. The output beam from the tube (Figure 1-4) is reconfigured to a round beam by a cylindrical mirror, then a flat mirror. The beam then passes through a knife edge filter to reduce diffraction effects and satellites. The beam is collimated prior to exiting the laser head by a zinc selenide lens. The beam shaping optics can be purged under conditions of high relative humidity to eliminate mode distortion.

Shutter Assembly

The shutter assembly contains the diode aiming laser, steering optic for the diode aiming laser, a water cooled beam energy dissipator, and the shutter mechanics energized by a solenoid. In the closed position, the extracavity shutter prevents the high power output beam from exiting the laser head without extinguishing lasing. The aiming beam is visible with the shutter closed. The shutter is electrically actuated remotely from the remote control unit. The shutter also provides its status output (open, closed, or fault) for external monitoring. The status is also displayed on the remote control unit and on the power module front panel.

Diode Aiming Laser

The diode aiming laser is located in the laser head. It provides a 1 mW visible output beam at 670 nm (red) to assist in positioning the output of the main beam which is invisible. The aiming beam is visible only when the shutter is closed and the AIMING BEAM On/Off switch on the remote control unit is set to On. The aiming laser is part of the shutter assembly.

Water Flow Switch

The water flow switch (Figure 1-3) allows monitoring of water flow in the laser head. When water flow is adequate, the water flow switch assembly will close the fault circuit in the laser head allowing the laser to operate. When water flow is inadequate, the fault circuit is opened preventing laser operation. The correct direction of water flow switch rotation is indicated on the assembly. Incorrect direction of water flow will also open the fault circuit. Water flow status is displayed on the power module front panel and is part of the fault indicating circuitry in the remote control unit.

Power Module

The power module contains the RF amplifier, DC power supply, line filter, Diamond digital interface (DDI) board, and an internal heat exchanger. These components are shown on Figure 1-2 and are described in the following paragraphs. Input power requirements are listed in Table 1-3.

Diamond Digital Interface (DDI) Board

The DDI board performs the following functions:

- Provides fault handling - fault status is displayed on the power module front panel.
- Provides an optically isolated interface for use with an external controller.

- Monitors system status - fault and warning status is displayed on the power module front panel.
- Provides an external interlock for connection to a user supplied safety interlock circuit.

Refer to Appendix A for additional information on interfacing an external controller to the DDI board.

RF Amplifier

The RF amplifier provides pulsed RF power to the laser head to ionize the laser gas mixture in the tube. The output pulse width and period are based on the pulse parameters typically selected on the remote control unit. The RF amplifier may produce over 3000 Watts of average RF output power.

The RF amplifier cable must always be connected to the laser head. Although protection is built into the RF amplifier, operating the RF amplifier with no load could cause damage. No maintenance or adjustments are required.

The RF amplifier also has the following features:

- Provides protection from duty cycles exceeding 60%.
- Limits the pulse width to less than 1 ms.
- Monitors forward and reflected RF power to and from the laser head.
- Contains a factory set VSWR limit that limits duty cycle to less than 10% in such faults as not having the RF cable connected.

DC Power Supply

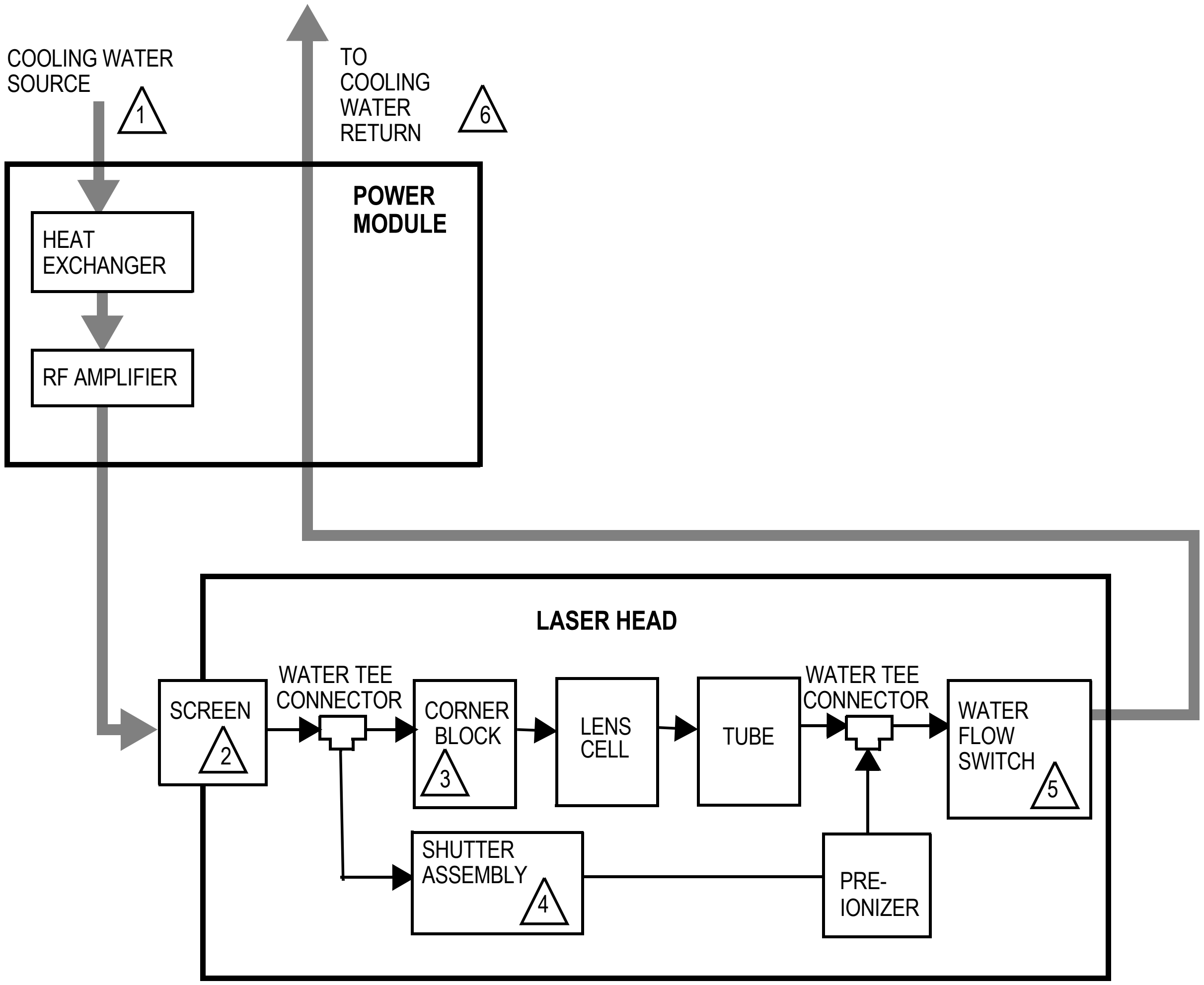
The +48 Volt DC air-cooled power supply (located in the power module) is the power source for the RF amplifier, the laser head, and the remote control unit. No maintenance or adjustments are required.

Line Filter

Various RF emissions originating from the DC power supply can be transmitted through the line cord and result in interference with other electrical equipment. The line filter eliminates RF emissions from the power module and results in a product that will not interfere with other equipment.

Diamond Cooling System

A block diagram of the cooling system is shown on Figure 1-5. The power module is also water cooled and is shown on Figure 1-2. Cooling water can consist of tap water or a closed loop system. In either case, cooling water must meet the requirements listed in Table 3-1.



△1 Cooling water can be supplied by facility water sources or from a closed loop heat exchanger. The cooling water source must meet the requirements listed in Table 3-1.

△2 The filter screen can be removed for cleaning.

△3 Refer to Figure 1-3 for the location of the corner block.

△4 The energy absorbed by the beam energy dissipater when the shutter is closed is dissipated by the cooling water.

△5 The water flow switch is part of the interlock circuit. A flow rate of less than 1.5 gallons per minute will activate the interlock circuit and cause the system to shut down.

△6 Check local codes governing discharge of cooling water into sewer system.

Figure 1-5. Cooling System Diagram

Maintenance Kit

A maintenance kit (Table 1-1) is supplied with each Diamond laser. This kit contains basic tools, materials, and parts for routine system maintenance.

Table 1-1. Maintenance Kit

ITEM	PURPOSE
Allen wrench set	General maintenance
Interlock defeat	Allows operation of the laser for maintenance with the laser head cover removed
Thermal alignment cards	Verify alignment in beam delivery optics.
Spare parts: Water screen Fuse: remote control unit, 1 Amp Fuse: power module, 3 Amp Emission indicator bulb O-rings (water screen)	Miscellaneous replacement parts

Table 1-2. Classification Levels for Standards or Requirements

CLASSIFICATION	LEVEL	APPLICABLE STANDARD OR REQUIREMENTS
Laser Emission Classification	Class 4 Class IV	EN60825-1 (2001) 21 CFR Subchapter J
Installation Category (Overvoltage Category)	Category 2	EN61010-1 (2001)
Pollution Degree	Degree 2	EN61010-1 (2001)

Table 1-3. Specifications

PARAMETER	SPECIFICATION
GUARANTEED PERFORMANCE	**K-300**
Average output power(1)	300 Watts
M^2 - Transverse mode quality	< 1.3 (K > 0.77)
Power range(1)	20-300 W
Pulse frequency	0-100 kHz
System life time(2)	1 year
TYPICAL PERFORMANCE	
Peak effective power	300-800 W
Optical pulse rise and fall time	< 40 µs
Pulse energy range	20-650 mJ
Pulse period (minimum)	10 µs (100 kHz)
Modulation pulse width range	4-1000 µsec
Output power stability(3)	< ± 8%
Beam waist diameter ($1/e^2$)	7.5 ± 0.8 mm 0.30 ± 0.03 in.
Beam divergence (full angle)	2.1 ± 0.3 mrad
Beam pointing stability(4)	< 200 µrad
Beam ellipticity	< 1.2 : 1
Beam polarization (parallel to baseplate)	Linear > 100 : 1
Wavelength	10.6 ± 0.2 µm
Tube shelf life time	> 1 year
Operating altitude	< 6,600 feet (< 2,000 meters)
Relative humidity	< 95% non-condensing at inlet coolant temperature
Tube gas consumption	None
Optional laser head purge (strongly recommended)	6 STD cubic feet/hour (2.8 liters per minute) Nitrogen 99.95% purity or 99.995% oil free air filtered with particle air filter to < 1 micron and dew point 10°C (18°F) lower than inlet cooling water temperature.

Table 1-3. Specifications (Continued)

PARAMETER	SPECIFICATION	
ENVIRONMENTAL		
Cooling water flow rate (minimum)	1.5 gpm (5.7 liters/minute)	
Inlet cooling water temperature range	10-35°C (50°F-95°F)	
Heat load	5 kW	
Inlet cooling water pressure	30-75 psi (210-520 kPa)	
Cooling water hardness (equivalent to $CaCO_3$)	< 250 mg/liter	
Ambient temperature (operational)	5°C-40°C (41°F-104°F)	
ELECTRICAL REQUIREMENTS		
Input voltage	208 VAC	380 VAC
Input current (maximum)	17 Amps, 3 phase(5)	10 Amps, 3 phase(5)
Recommended fuse or circuit breaker	20 Amps	15 Amps
Line frequency	50-60 Hz	
WEIGHT		
Laser head	79 pounds (35.9 kg)	
Power module	140 pounds (63.6 kg)	

The above specifications subject to change without notice.

(1) Guaranteed at 600 µs pulse width at 60% duty cycle with the inlet cooling water at 25°C. Allow a 1%/°C power derating for inlet cooling water to a temperature of 35°C.

(2) See Appendix D for the full system warranty.

(3) Measured as ±(Pmax – Pmin)/2 Pmax from a cold start at 25°C for the output power range for pulse width ≥ 4 µs.

(4) Full angle within a ±5°C inlet cooling water temperature range (constant frequency and pulse width).

(5) With ground.

OPERATOR'S MANUAL

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CHAPTER TWO
SAFETY AND COMPLIANCE ISSUES

COHERENT

Optical Safety

The Diamond laser has undergone extensive testing to ensure that, with proper usage, it is a safe and reliable device.

Laser light, because of its special properties, poses safety hazards not associated with light from other sources. The safe use of lasers requires that all laser users and everyone near a laser be aware of the dangers involved in laser operation.

Direct eye contact with the output beam from the laser will cause serious damage and may cause blindness.

All personnel in the same room as the laser or anyone who may be exposed to the laser beam should be informed that a laser is in operation. All personnel must wear laser safety glasses which protect against the wavelengths in use.

Exercise caution to protect against specular reflections since reflections at the Diamond wavelength are invisible.

Eye safety is a great concern when using a high-power laser such as the Diamond. There are often many secondary beams present at various angles near the laser. These beams are specular reflections of the main beam from polished surfaces. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are also powerful enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol, gasoline, ether, and other solvents and can damage the light-sensitive elements in video cameras, photomultipliers, and photodiodes.

Coherent provides the following recommendations to promote the safe use of the Diamond. Operators are advised to adhere to these recommendations and employ sound laser safety practices at all times.

- Use protective eyewear when operating the laser and guard against inadvertent exposure to skin or clothing. Select eyewear which is suitable for use with the wavelengths and radiation intensity that the laser emits. Refer to the *Laser Focus World Buyer's Guide* or to the *Rockwell Laser Industries catalogue* for suppliers of protective eyewear.
- Do not remove the protective cover from the laser head. During normal operation, internal reflections are confined within the laser head and pose no safety hazard.

- Never look directly into the laser output port when the power is on.
- Set up the laser and all optical components used with the laser away from eye level. Provide enclosures for the laser beam.
- Use the laser in a room with access controlled by door interlocks. Post warning signs. When operating the laser, limit access to the area to individuals who are trained in laser safety.
- Avoid operating the laser in a darkened environment.
- Do not use the laser in the presence of flammables, explosives, or volatile solvents such as alcohol, gasoline, or ether.

For additional information on laser safety, refer to the following publications:

- *Laser Safety Comes to Light* (videotape). ©Coherent, Inc., 1988.
- *American National Standard for the Safe Use of Lasers, Z136.1,* American National Standards Institute, 1993.
- *Performance Standard for Laser Products*. FDA., (FR-40) (148): 32252-32265. Department of Health, Education and Human Service Bureau of Radiological Health, July 31, 1974.
- *Laser Safety Guide,* Laser Institute of America. (9th Edition). Orlando, FL 1993.
- D. Sliney and M. Wolbarsht. *Safety with Lasers and Other Optical* Sources. Plenum Publishing Company, New York, N.Y., 1980.
- *Safety of Laser Products, Part 1: Equipment Classification, Requirements, and User's Guide.* EN60825-1: 1994, European Committee for Electrotechnical Standardization, Central Secretariat, rue de Stassart 35, B-1050 Brussels, Belgium.

Electrical Safety

The input voltage to the Diamond system is 208 VAC or 380 VAC using three phases with ground. These voltages can be lethal. Every portion of the electrical system should be treated as if it is at a dangerous voltage level. All the metal parts of the tube should be considered extremely dangerous.

The laser head is equipped with a safety interlock on the access covers. Removal of the cover during operation will cause the laser to cease operation.

The DC power supply and RF amplifier covers (located inside the power module) should never be removed. There are no user serviceable components inside.

Laser Head

High voltages are present in the laser head when power is on. The laser head cover is interlocked and should not be opened during normal operation. Maintenance procedures described in Chapter Six, Maintenance and Troubleshooting, may require opening the cover. Please read the appropriate manual sections carefully before attempting any maintenance of components housed in the laser head.

Safety Features and Compliance to Government Requirements

The following features are incorporated into the instrument to conform to several government requirements. The applicable United States Government requirements are contained in 21 CFR, subchapter J, part II administered by the Center for Devices and Radiological Health (CDRH). The European Community requirements are generally implemented through the Low Voltage Directive as published in 73/23/EEC and amended in 93/68/EEC. The detailed laser safety standards are published in EN 60825-1: 2001.

Laser Classification

The governmental standards and requirements specify that the laser must be classified according to the output power or energy and the laser wavelength. All Diamond lasers are classified as Class IV based on 21 CFR, subchapter J, part II, section 1040-10 (d). According to the European Community standards, Diamond lasers are classified as Class 4 based on EN 60825-1, Clause 9. The aiming beam is classified as Class II or Class 2 according to the same documents, respectively. In this manual and other documentation of the Diamond laser, the classification will be referred to as Class 4.

Protective Housing

The laser head has a protective housing which prevents human access in excess of the limits of Class 1 radiation except for the output beam which is Class 4 and the aiming beam which is Class 2 [CFR 1040.10 (f)(1) and Table 1-A/EN 60825-1, Clause 4.2].

Safety Interlocks

The laser head cover is equipped with an interlock which prevents the laser from operating with the head cover removed.

Means are provided to defeat the laser head interlock for maintenance operations. Only qualified service personnel should operate the laser with the interlock defeated. There is the danger of lethal electrical shock, skin and eye injury which may result in permanent blindness [CFR 1040.10(f)(2)/ EN60825-1, Clause 4.3].

Remote Interlock Connector

Pins 14 and 15 on the INTERLOCK + CONTROL connector on the remote control unit rear panel are provided for use as an external interlock connection. These pins must be shorted together for the laser to operate. The laser is shipped with a shorting connector installed which can be replaced with a user furnished external interlock circuit [CFR 1040.10(f)(3)/ EN60825-1, Clause 4.4].

An external interlock connector (labelled INTERLOCK) is also provided on the power module rear panel for use as an external interlock connection.

Refer to Chapter Three, Utility Requirements and System Installation, for information on connecting an external interlock circuit and refer to Appendix A, Connector Pinouts, for the pin numbers of the interlock connectors.

Key Control

The laser cannot be turned on or operated until the keyswitches on the remote control unit and on the power module are in the ON position [CFR 1040.10(f)(4)/ EN60825-1, Clause 4.5].

Laser Radiation Emission Indicator

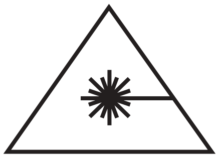
Laser radiation emission indicators are turned on several seconds before Class 4 laser emission can occur. The indicators are visible without exposing the operator to laser emission. A green laser emission indicator (labelled LASER EMISSION) is located on the remote control unit and the power module. This indicator is visible without exposing the operator to laser emission [CFR 1040.10(f)(5)/EN60825-1, Clause 4.6].

Shutter

A remote controlled shutter is provided on the Diamond. The shutter can block all bodily access to Class 4 laser radiation without turning off the laser [CFR 1040.10 (f)(6)/EN60825-1, Clause 4.7]. The 1 mW, 670 nm Class II aiming beam which is visible when the shutter is closed is controlled by a remote On/Off switch located on the remote control unit.

Operating Controls

Electronic controls are located on the remote control unit and on the power module. All controls are located in such a way that the operator need not be exposed to laser emission while manipulating the controls [CFR 1040.10(f)(7)/EN60825-1, Clause 4.8].



Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

Location of Safety Labels

Refer to Figure 2-1 for a description and location of all required safety labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification [CFR 1040.10(g), CFR 1040.2, and CFR 1010.3/EN60825-1, Clause 5].

Radiated Emission Compliance

The Diamond K-300 Performance Package System has been tested and verified that it is in compliance with the radiated emission limits of FCC Rules contained in 47 CFR Part 18 Subpart C for industrial, scientific, and medical equipment, and the European Community Requirements EN55011: 1998 (CISPR11) Class A. The following information to the user is provided in compliance with United States Government requirements contained in 47 CFR 18.213.

Interference Potential of the System

In our testing in a variety of laboratory and industrial settings, we have not found any significant electrical interference that can be traced to the Diamond K-300 system. The Diamond K-300 system is excited by an RF power supply operating at 81.36 MHz. The RF power is modulated at the same pulse width and pulse period selected in operating the laser.

Maintenance of the System

In order to have the Diamond K-300 laser system operate properly, the RF connectors between the power module and the laser head must be always kept tight. No special tooling is required since a finger tight connections is satisfactory. We recommend checking these connections on a monthly interval to ensure that they are tight.

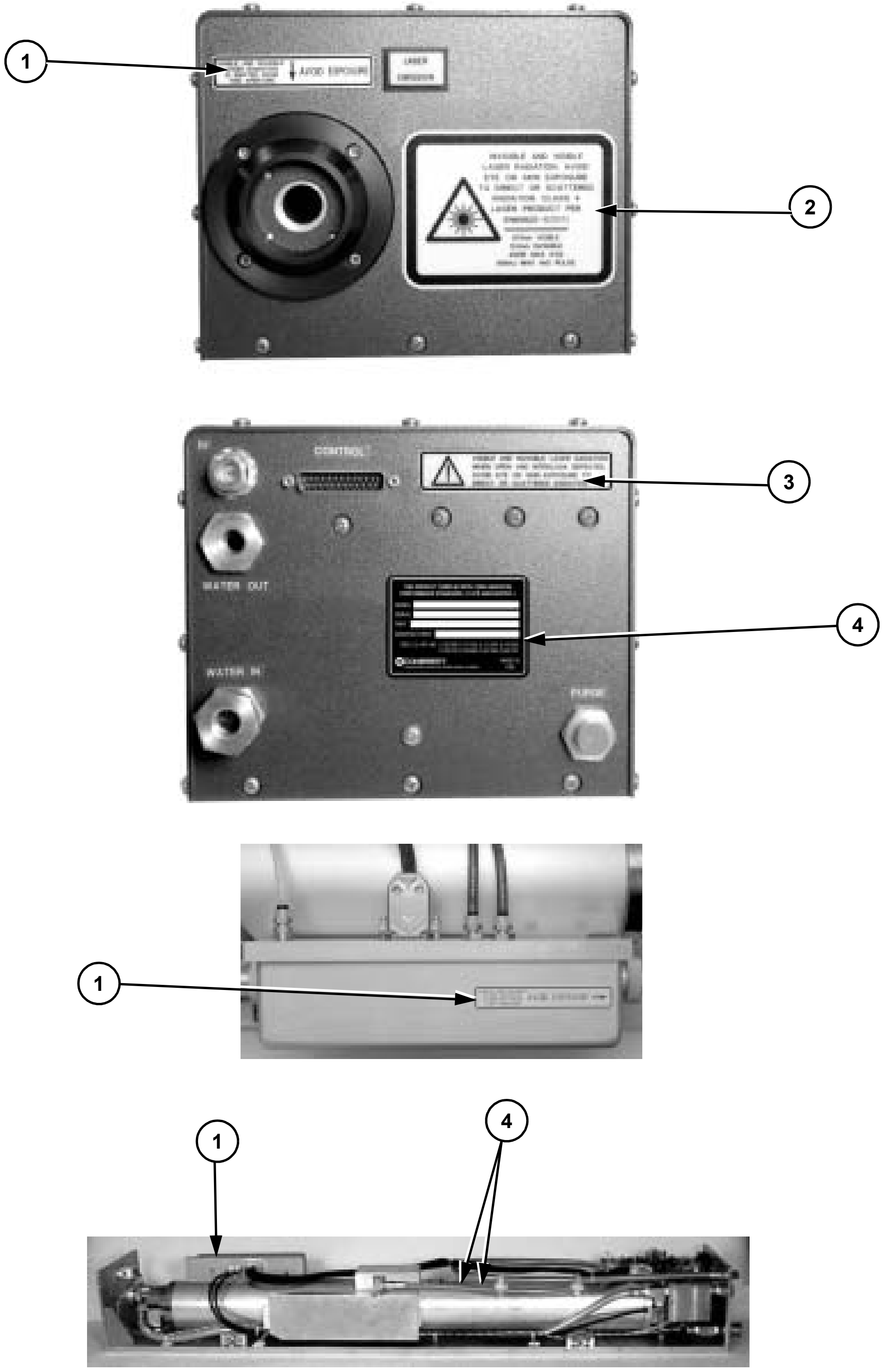
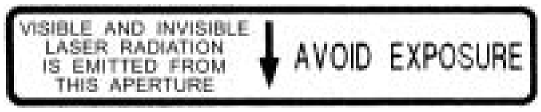


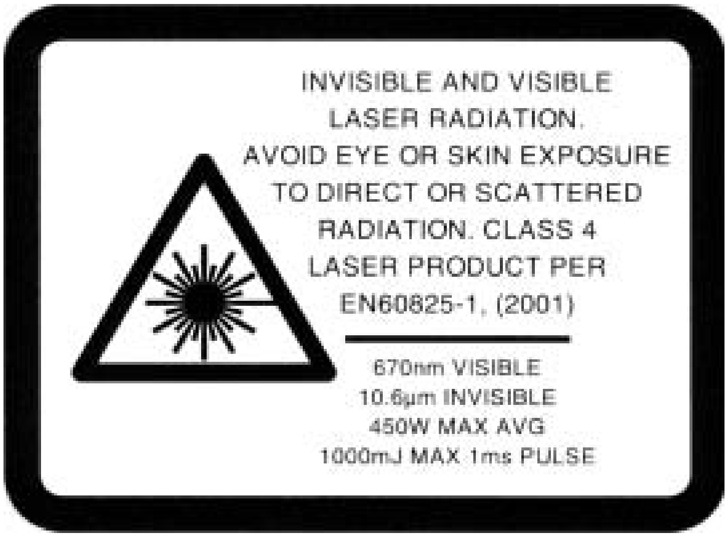
Figure 2-1. Location of Safety Labels (Sheet 1 of 2)



VISIBLE AND INVISIBLE
LASER RADIATION
IS EMITTED FROM
THIS APERTURE

↓ AVOID EXPOSURE

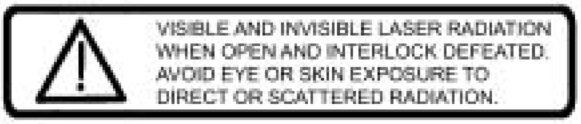
1.



INVISIBLE AND VISIBLE
LASER RADIATION.
AVOID EYE OR SKIN EXPOSURE
TO DIRECT OR SCATTERED
RADIATION. CLASS 4
LASER PRODUCT PER
EN60825-1, (2001)

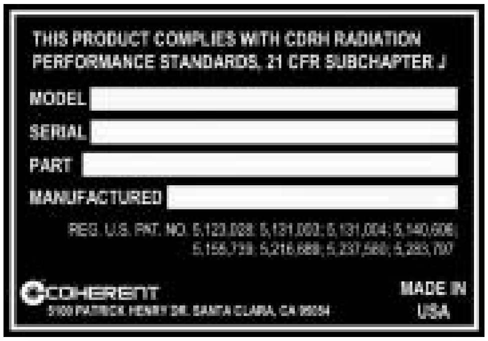
670nm VISIBLE
10.6µm INVISIBLE
450W MAX AVG
1000mJ MAX 1ms PULSE

2.



VISIBLE AND INVISIBLE LASER RADIATION
WHEN OPEN AND INTERLOCK DEFEATED.
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION.

3.



THIS PRODUCT COMPLIES WITH CDRH RADIATION
PERFORMANCE STANDARDS, 21 CFR SUBCHAPTER J

MODEL
SERIAL
PART
MANUFACTURED

REG. U.S. PAT. NO. 5,123,028; 5,131,003; 5,131,004; 5,140,606;
5,155,739; 5,216,689; 5,237,580; 5,283,797

COHERENT
5100 PATRICK HENRY DR. SANTA CLARA, CA 95054

MADE IN
USA

4.

Figure 2-1. Location of Safety Labels (Sheet 2 of 2)

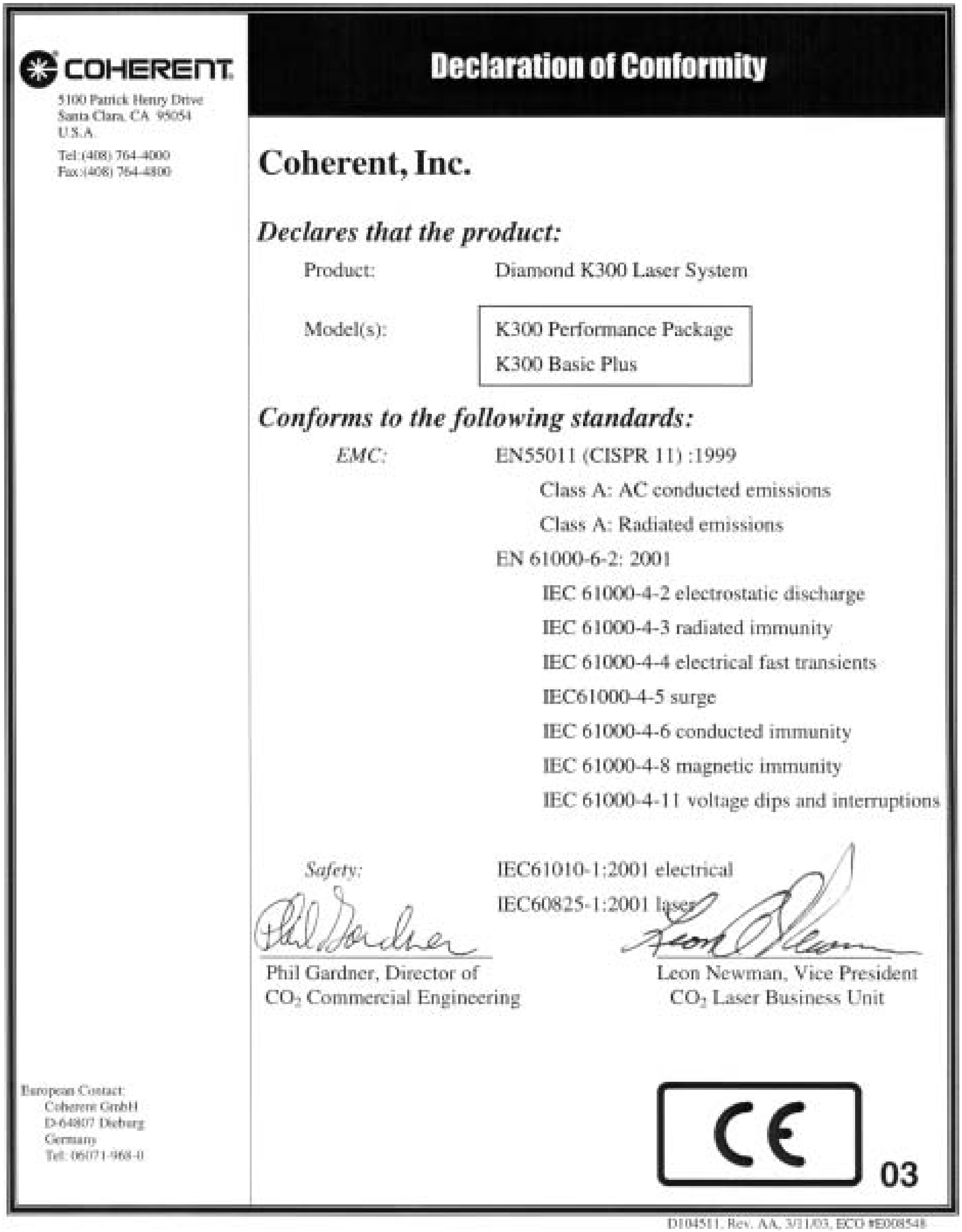
Simple Measures to Correct Interference

If the Diamond K-300 system is determined to be the source of interference with other equipment the following steps can be taken to minimize this interference:

1. Check to make sure that the RF cable connectors are all tight. Also check all the connections at the control cable connections to the laser head, power module, and remote control unit.
2. When possible, separate the RF cable of the Diamond system and the signal cables to the piece of equipment that is experiencing the interference problem.
3. Use shielded cables including control cables to the unit experiencing the interference problem. The shield should be grounded.

Declaration of Conformity

The following Declaration of Conformity comply with ISO/IEC Guide 22 and EN 45014. In this declaration, the manufacture's name and address are identified along with the products and the applicable standards that are recognized in the European community.



COHERENT

5100 Patrick Henry Drive
Santa Clara, CA 95054
U.S.A.

Tel:(408) 764-4000
Fax:(408) 764-4800

Declaration of Conformity

Coherent, Inc.

Declares that the product:

Product: Diamond K300 Laser System

Model(s):
K300 Performance Package
K300 Basic Plus

Conforms to the following standards:

EMC:

EN55011 (CISPR 11) :1999
- Class A: AC conducted emissions
- Class A: Radiated emissions

EN 61000-6-2: 2001
- IEC 61000-4-2 electrostatic discharge
- IEC 61000-4-3 radiated immunity
- IEC 61000-4-4 electrical fast transients
- IEC61000-4-5 surge
- IEC 61000-4-6 conducted immunity
- IEC 61000-4-8 magnetic immunity
- IEC 61000-4-11 voltage dips and interruptions

Safety:

IEC61010-1:2001 electrical
IEC60825-1:2001 laser

Phil Gardner, Director of
CO_2 Commercial Engineering

Leon Newman, Vice President
CO_2 Laser Business Unit

European Contact:
Coherent GmbH
D-64807 Dieburg
Germany
Tel: 06071-968-0

CE 03

D104511, Rev. AA, 3/11/03, ECO #E008548

Table 2-1. Declaration of Conformity

OPERATOR’S MANUAL

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CHAPTER THREE
UTILITY REQUIREMENTS AND SYSTEM INSTALLATION

Utility Requirements

The Diamond laser requires electrical power. Facility water is required for cooling the laser head and power module. Electrical power, environment, and cooling water must meet the specifications in Table 3-3.

Electrical Service

The power module requires three phase power at either 208 or 380 VAC with a ground. This input can be either at 50 or 60 Hz for both of the input voltages. The unit is designed for permanent installation with either a switched fuse box or switchable circuit breaker located close to the unit or within easy reach of the operator. The fuse box or circuit breaker shall be marked as the disconnecting device for the laser unit. Each phase must have a fuse or circuit breaker and wire size as shown in Table 3-3. See Figure 3-8 for laser system interconnection diagram.

The input electrical power to the Diamond system must be at equal voltage (±10%) for all three phases. If there is equipment operating on the same electrical input which produces a large load on a single phase or if one phase drops out, this can lead to failure of the DC power supplies. A reduction of the input voltage of one phase would be evidence of an imbalance loading of the electrical input. It is recommended for conditions where one phase can drop out to add phase monitoring equipment to the electrical input of the laser. It should be able to shut down the input power in less than 5 seconds to prevent damage to the DC supplies.

The laser head requires a protective earth ground. See Figure 3-8, Figure 4-8 and Table 4-5, item 6.

Cooling Water

The Diamond laser head and the power module require a flow of cooling water. Because the properties of the cooling water are important for laser performance, ensure that the conditions remain within the tolerance limits listed in Table 3-1 through Table 3-3 at all times. Check local and state regulations which may control use of city water for cooling. Some regulatory codes will not allow the discharge of cooling water into the sewer system.

Tap water temperature and pressure can vary with the time of day and season of the year. A closed-loop cooling system can be used to obtain consistent laser performance. The temperature of the inlet cooling water should always be above the dew point in order to prevent damage to the laser head and RF amplifier.

Table 3-1. Recommended Minimum Inlet Cooling Water Temperature for Celsius Temperature Scale

ROOM TEMPERATURE (°C)	**MAXIMUM RELATIVE HUMIDITY**							
	30%	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**95%**
5	20	20	20	20	20	20	20	20
10	20	20	20	20	20	20	20	20
15	20	20	20	20	20	20	20	20
20	20	20	20	20	25	25	25	25
25	25	25	25	25	30	30	30	30
30	30	30	30	30	35	35	35	35
35	35	35	35	35	35	35	35	35
40	35	35	35	35	35	N/A	N/A	N/A

1. The minimum inlet cooling water temperature should account for variations in cooling water temperature with the thermal load, temperature stability of the cooling water system, and seasonal variations in cooling water temperature.
2. N/A indicates operation under these conditions is not acceptable since condensation will occur on the laser system. Either the ambient temperature must be reduced or the relative humidity must be reduced before operating the laser.

Selecting The Correct Cooling Water Temperature

The cooling water of the Diamond system can condense moisture from the air when the temperature of the cooling water is lower than the dew point of the air. The system must not operate under these conditions since it will lead to catastrophic failure in both the laser head and the RF power supply. When failures occur in either the optics or the RF power supply it must be returned to the factory for repair. Under most conditions, it is recommended to select the inlet cooling water temperature at room temperature or at least 25°C (77°F). This following information provides recommendations for operating conditions outside of the normal temperature and humidity range.

The conditions that lead to a situation where there can be condensation are warm and humid weather combined with water that is cooler than the surroundings. High risk conditions which will lead to condensation are:

- Operating the laser in a room that is not air conditioned in high humidity conditions

- Using cooling water that is not temperature controlled
- Leaving the cooling water on when the laser is not operating for extended time periods

The information required to determine if the cooling water temperature will lead to condensation is:

- Room temperature
- Relative humidity

Table 3-2. Recommended Minimum Inlet Cooling Water Temperature for Fahrenheit Temperature Scale

ROOM TEMPERATURE (°F)	**MAXIMUM RELATIVE HUMIDITY**							
	30%	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**95%**
41	68	68	68	68	68	68	68	68
50	68	68	68	68	68	68	68	68
60	68	68	68	68	68	68	68	68
70	70	70	70	70	77	77	77	77
80	77	77	77	77	86	86	86	86
90	86	86	86	86	95	95	95	95
95	95	95	95	95	95	95	95	95
104	95	95	95	95	95	N/A	N/A	N/A

1. The minimum inlet cooling water temperature should account for variations in cooling water temperature with the thermal load, temperature stability of the cooling water system, and seasonal variations in cooling water temperature.
2. N/A indicates operation under these conditions is not acceptable since condensation will occur on the laser system. Either the ambient temperature must be reduced or the relative humidity must be reduced before operating the laser.

Since the weather conditions change, these factors need to be periodically check especially in the spring and summer seasons. In environments that are air conditioned, we recommend setting the cooling water temperature to 25°C (77°F). As explained below for conditions that are not air conditioned, we recommend that the cooling water temperature be increased to the air temperature to avoid condensation in humid climates.

The recommended inlet cooling water temperature is provided in Table 3-1 and Table 3-2 for the complete operating temperature range of the Diamond laser system. Note that the first table is for temperature on the Celsius scale and the second is for temperatures on the Fahrenheit scale. To use this chart, find the row with the closest room temperature. Next read across until you find the column with the nearest relative humidity for the room with the laser. The number in the box is the recommended temperature for the inlet cooling water. If a closed loop cooling system is being used then select this temperature as the temperature set point. As an example, if the current room temperature is 28°C and the relative humidity is 68%, then the recommended inlet cooling water temperature is 35°C and the nearest relative humidity is 70%.

Selecting the cooling water temperature must also take into account changes in the cooling water temperature. For a closed loop cooling water system, there can be variations in the water temperature due to changes in the thermal load and the response time of temperature controller. The number given by the table will be the minimum water temperature that should be observed for the current room temperature and humidity conditions.

In many climates, the cooling water temperature should be changed due to seasonal variations in the ambient conditions. For example in times of high relative humidity and high room temperatures, the cooling water temperature will have to be increased to avoid problems with condensation. Under extreme conditions of temperature and humidity, the laser should not be operated as noted in Table 3-1 and Table 3-2. This can be solved by air conditioning the room with the laser to reduce both the room temperature and the humidity.

When using tap water as cooling source, seasonal variations in the water temperature often can lead to conditions that will produce condensation. In this case, mixing some hot water with the inlet cooling water will be required to eliminate condensation or alternatively reducing the room temperature and humidity with an air conditioning system.

Optics Purge Gas

The Diamond laser is used in a wide range of material processing which often has by-products of dust, smoke, fumes, oil and various gases. These by-products can cause contamination of the laser head optics as well as the beam delivery optics. This will severely degrade the system performance and can lead to damage of the optical components. Coherent, Inc. strongly recommends passing a purge gas through the laser head and then into the beam delivery optics can prevent optics damage. Also under some conditions of high

Table 3-3. Utility Requirements

PARAMETER	REQUIREMENT	
ELECTRICAL		
Input voltage	**208 VAC**	**380 VAC**
Input frequency	50 to 60 Hz	50 to 60 Hz
Maximum current	17 amps	10 amps
Fuse or circuit break	20 amps	15 amps
Wire gauge (minimum)(1)	12	12
Wire cross sectional area (minimum)(1)	4.0 mm^2	4.0 mm^2
WATER (2)		
Cooling water flow rate (minimum)	1.5 gpm (5.7 liters/minute)	
Inlet pressure(3)	30 to 75 psi (210 to 520 kPa)	
Pressure differential(4)	30 psi (210 kPa) minimum	
Inlet cooling water temperature range	10°C to 35°C (50°F to 95°F)	
Hardness (equivalent to $CaCO_3$)	< 250 mg/liter	
pH	5 to 9	
Particulate size	< 200 microns in diameter	
Heat load (5)	5 kW	
ENVIRONMENTAL		
Ambient temperature (operational)	5°C to 40°C (41°F to 104°F)	
Relative humidity	<95% non-condensing for inlet water temperatures	
Operating altitude	<6,600 feet (<2,000 meters)	
Purge Gas (strongly recommended)	6.0 STD cubic feet/hour or 2.8 liters/min at about 5 psi (35 kPa) of 99.95% nitrogen or 99.995% oil-free air with particle filter to 1 micron and dew point 10°C (18°F) lower than incoming water temperature.	

(1) Wire insulation should be rated for 85°C (185°F) or higher. The fuse or circuit breaker ratings and the wire sizes are based on generally accepted standards but in some localities there maybe specific requirements in electrical or building codes. These codes should be consulted to ensure compliance.

(2) Refer to the paragraph titled Cooling Water, located in this chapter for additional information including discharge of cooling water.

(3) Inlet pressure is based on the standard (30 foot total) water lines furnished with the system. If different lengths are used, the difference must be taken into account when determining the inlet pressure.

(4) Between the inlet and return water lines. Pressure differential is based on the standard (30 foot total) water lines furnished with the system. If different lengths are used, the difference must be taken into account when determining the pressure differential.

(5) If a closed-loop cooling system is used, it must have sufficient capacity to handle heat loads of 5 kW in addition to meeting the other water requirements listed in this table.

humidity, the laser beam can be distorted by optical absorption of the laser beam by water vapor. This effect can be totally eliminated also by a proper gas purge.

The gas purge in the Diamond lasers enters the corner block and flows through the beam shaping optics on through the shutter assembly and out the exit aperture of the laser head. The threaded output bezel provides a convenient connection to the beam delivery optics while maintaining a gas seal at this junction.

The quality of the purge gas is extremely important factor for trouble free operation of the Diamond laser system. The preferred purge gas is nitrogen with a purity of 99.95%. In many facilities, nitrogen of the purity level is provided from a nitrogen boil of a liquid nitrogen source.

If nitrogen is not available then the alternate source is oil-free and dry compressed air. Compressed air is also available in many facilities but typically is contaminated with water and oil vapors. The purity requirements for the compressed air are:

1. Filtered to remove particles larger than 1 micron.
2. Dried so that dew point is 10°C (18°F) lower than the inlet cooling water temperature to the Diamond laser system.
3. Oil free to better than 99.995%.

An optional filter kit with Teflon tubing can be installed to obtain this quality of air. The proper installation of the filter kit is shown in Figure 3-1 and is attached to the laser at the inlet fitting labeled PURGE. Note if the dew point cannot be achieved then a drier must be installed. Place the drier between the final filter stage and the laser head. A suitable drier is Balston 7601. The coalescing filter kit with Teflon tubing is available from Coherent or your local Coherent representative. See Parts List in the appendices for the part number of the filter kit and replacement filter cartridges.

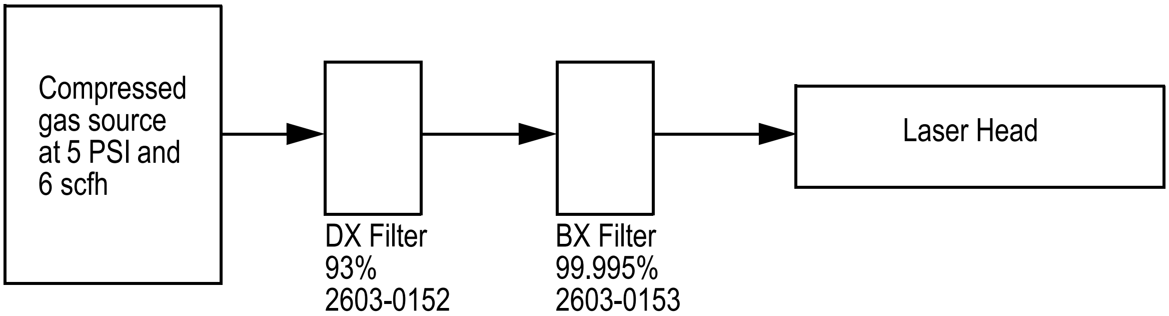


Figure 3-1. Block Diagram Illustrating Installation of Optional Purge Kit

It is the responsibility of the customer to provide nitrogen or compressed air that meets the specifications stated above. The warranty of the laser is voided and the customer is responsible for all cost of repair or damage to the laser.

See the Preventative Maintenance section in Chapter Five for the routine maintenance required for the purge gas filters.

Installation

Installation consists of:

- Preparing the facility for installation
- Performing a receiving inspection
- Unpacking and inspecting system components
- Mounting the laser system components
- Interconnecting the electrical cables
- Connecting the water lines to the water source and drain
- Turning on the laser system

Table 3-4. Equipment Required for Installation (Not Furnished With System)

EQUIPMENT	QUANTITY	USE
Electrical wiring	As required	See Table 3-3 for correct wire size.
Mounting bolts	8	The mounting bolts secure the laser head and power module. • 0.375-16UNC-2B (inches, domestic) • M10 x 1.5 (multi-national)
Optics purge	As required	1/4 inch (0.63 cm) O.D. Teflon, polyethylene or polypropylene tubing for purge gas.

Preparing the Facility for Installation

Ensure facility electrical, water, and nitrogen (optional) are adequate for laser operation.

The facility outlet for the power module must have a fuse or circuit breaker on each phase. Consult the local electrical or building codes to determine the correct rating for the fuse or circuit breaker.

Refer to the paragraph titled Electrical Service, and to Table 3-3 for electrical requirements. Refer to the paragraph titled Cooling Water, and to Table 3-1, Table 3-2, and Table 3-3 for water requirements.

Refer to the paragraph titled “Optics Purge Gas” and to Table 3-3 for purge gas requirements.

Receiving Inspection

Before unpacking the Diamond, inspect all shipping containers and note any damage. Any indication of damage should be noted on the bill of lading. The shipping carrier is responsible for damage in transit. Immediately report damage to the shipping carrier and to Coherent.

Unpacking

To avoid equipment damage, exercise care when removing wrapping materials.

To minimize the risk of functional or cosmetic damage, unpack the laser system at the installation site. While unpacking the Diamond laser, verify that all items on the packing list have been received. Save all containers and packing material including the water line end caps. They will be required if it becomes necessary to re-ship the equipment.

Mounting Laser System Components

The laser head and power module have provisions for permanent mounting. Refer to the figures listed below for overall dimensions, location of the mounting holes and depth of mounting bolts.

- Laser head, Figure 3-2
- Power module, Figure 3-3

Refer to Figure 3-7, Mounting Distances, prior to mounting the laser components in order to take into consideration cable lengths.

Also note the precision beam alignment slots (Figure 3-2) on the bottom of the laser head which serve as a reference for output beam alignment. This also makes it possible to quickly interchange a replacement laser head with a minimum of optics alignment to the user beam delivery system.

The lifting and carrying of the laser head should be done by two people. The laser head should be held by the base. Once it is in the final location, it should be anchored using the mounting holes provided in the base.

The power module should be lifted by two people using the handles on the side of the unit. Also once it is in the final location, it should be anchored using the mounting holes provided the base.

Power Module Input Voltage

The power module can operate with two different input voltage ranges. The lower voltage range is 208 VAC (±10%) and the higher voltage range is 380 VAC (±10%). Either service requires a three phase with a ground. To determine the selected voltage range of

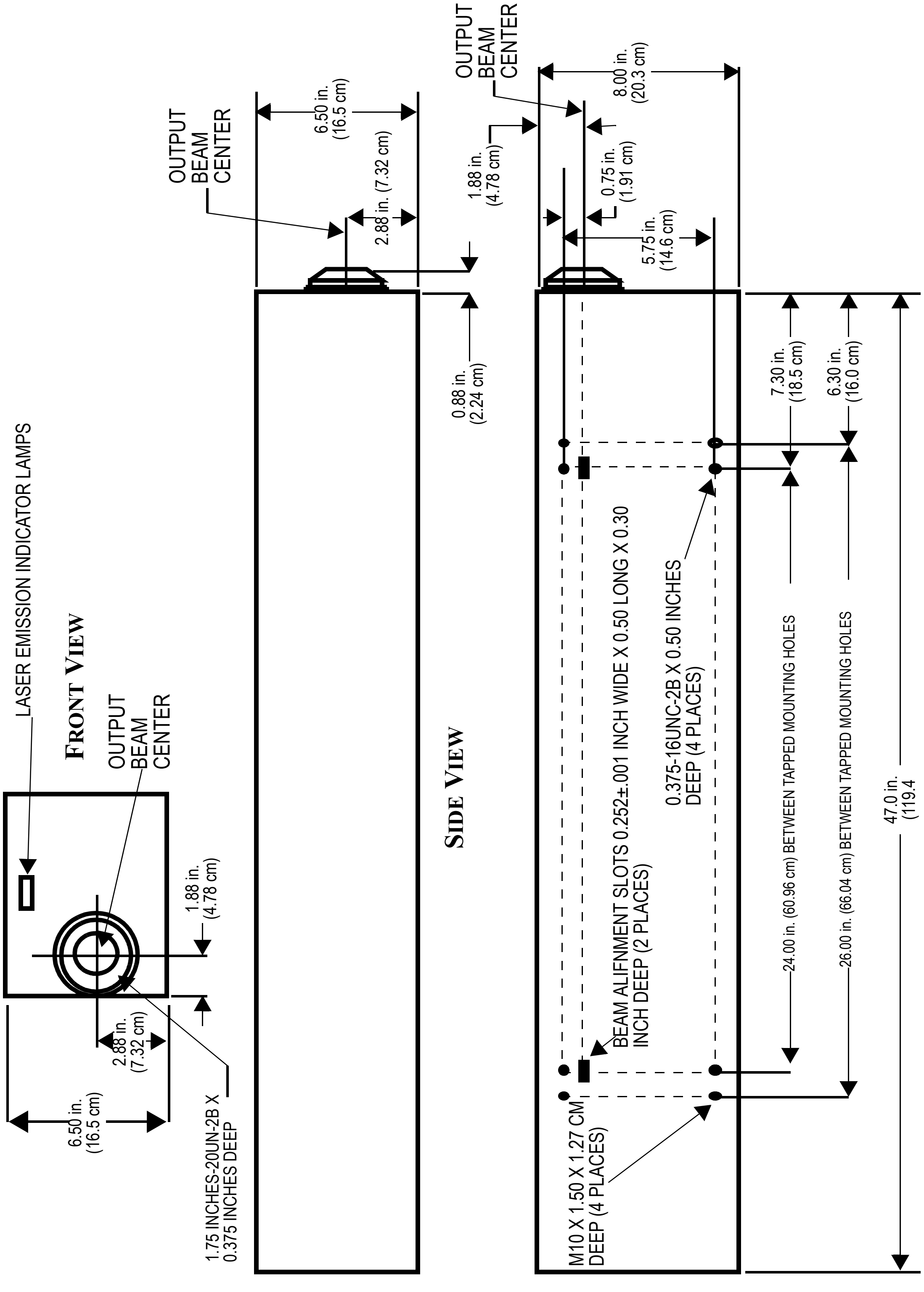
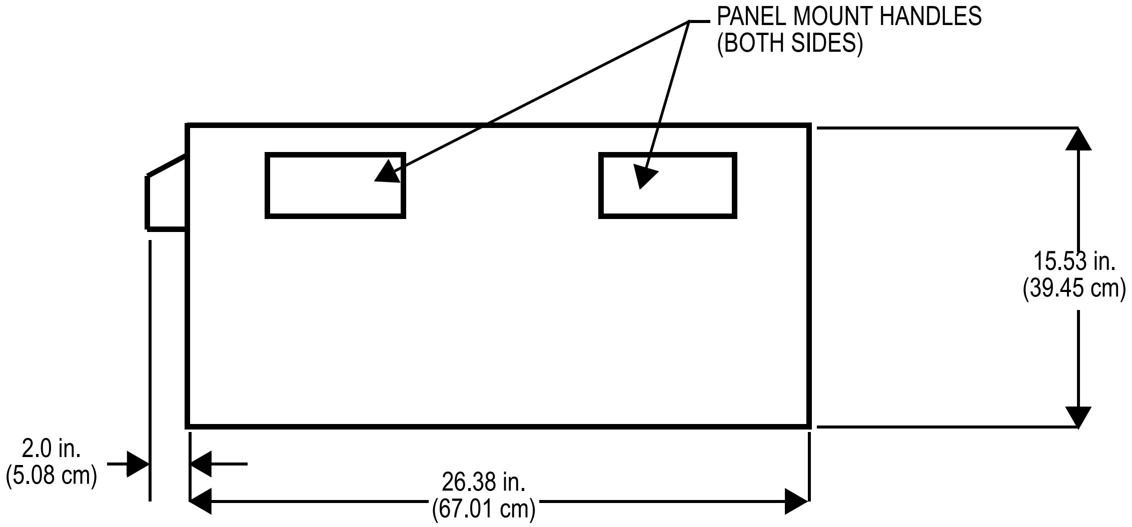
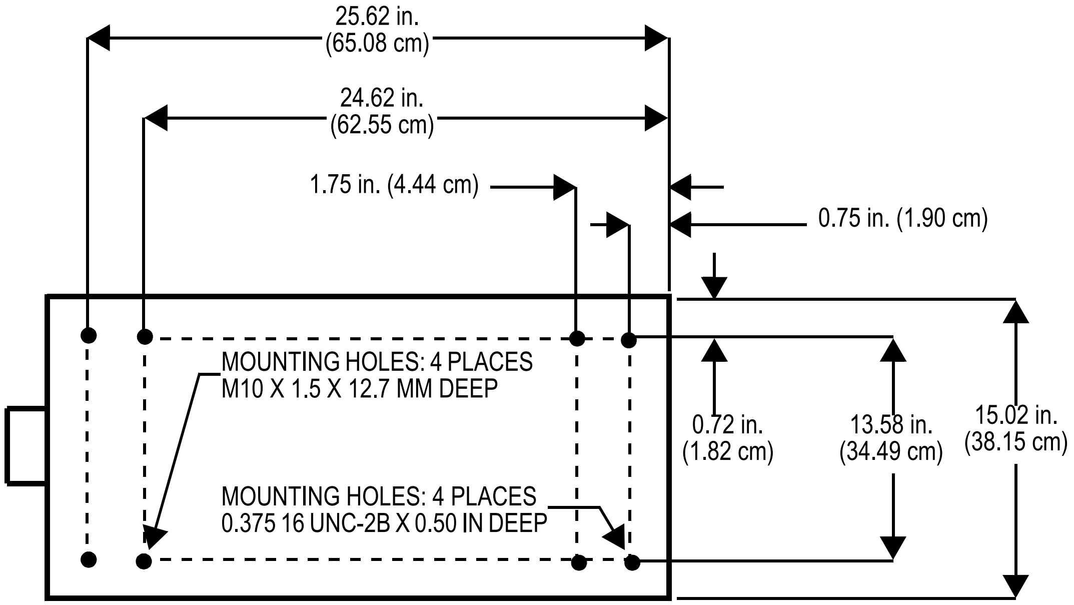

FRONT VIEW
LASER EMISSION INDICATOR LAMPS
OUTPUT BEAM CENTER
1.88 in. (4.78 cm)
2.88 in. (7.32 cm)
6.50 in. (16.5 cm)
1.75 INCHES-20UN-2B X 0.375 INCHES DEEP
SIDE VIEW
OUTPUT BEAM CENTER
6.50 in. (16.5 cm)
2.88 in. (7.32 cm)
0.88 in. (2.24 cm)
BOTTOM VIEW
OUTPUT BEAM CENTER
8.00 in. (20.3 cm)
1.88 in. (4.78 cm)
0.75 in. (1.91 cm)
5.75 in. (14.6 cm)
7.30 in. (18.5 cm)
6.30 in. (16.0 cm)
BEAM ALIFNMENT SLOTS 0.252±.001 INCH WIDE X 0.50 LONG X 0.30 INCH DEEP (2 PLACES)
0.375-16UNC-2B X 0.50 INCHES DEEP (4 PLACES)
24.00 in. (60.96 cm) BETWEEN TAPPED MOUNTING HOLES
26.00 in. (66.04 cm) BETWEEN TAPPED MOUNTING HOLES
47.0 in. (119.4
M10 X 1.50 X 1.27 CM DEEP (4 PLACES)

Figure 3-2. Laser Head Dimensions and Mounting Hardware Locations

power module inspect the voltage label on the rear panel of the power module. The location of this label is shown in Figure 3-4 and it illustrates a power module setup for an input voltage of 380 VAC.



SIDE VIEW



BOTTOM VIEW

Figure 3-3. Power Module Dimensions and Mounting Hardware Location

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Ensure that the correct input voltage has been selected on the power module before applying input power to the power module. Failure to have the proper input voltage will damage the DC power supplies in the power module.

Facility input power must match the range selected on the rear panel of the power module before any power is applied to the unit. If the input voltage is not correct see the following paragraph for the procedure to change the voltage range.

Changing Input Voltage for Power Module

This section describes the method to change the input voltage to the power module. The input voltage to this unit can be selected for operation at either 208 or 380 VAC. The selected voltage is visible on a label on the rear panel of the power module. This label indicates the operating voltage, the maximum current, wiring configuration, and frequency range. Changing the input voltage should be done by a skilled technician trained to work with high voltages. The tools required to change the input voltage are an Allen wrench. The rear panel of the power module is shown in Figure 3-4 through Figure 3-6 during the voltage changing operation. To change the input voltage range of the power module follow each of the steps below.

The power module must not be connected to the input power when the input voltage is being changed. Failure to comply is a safety risk to personnel and also will damage the DC power supplies in the power module.

---

1. Ensure that the power module is not connected to any source of input power. Failure to comply is both a safety hazard and will damage the DC power supplies located inside the power module.
2. Remove the ten Allen head screws retaining the input voltage selection assembly. Remove the panel covering this assembly.
3. Pull the assembly straight out of the four locating pins. The power module should now appear as shown in Figure 3-5.
4. Rotate the input voltage selection assembly by one half a turn.
5. Align the input voltage selection assembly to the four locating pins and slide back into place. The rear of the power module

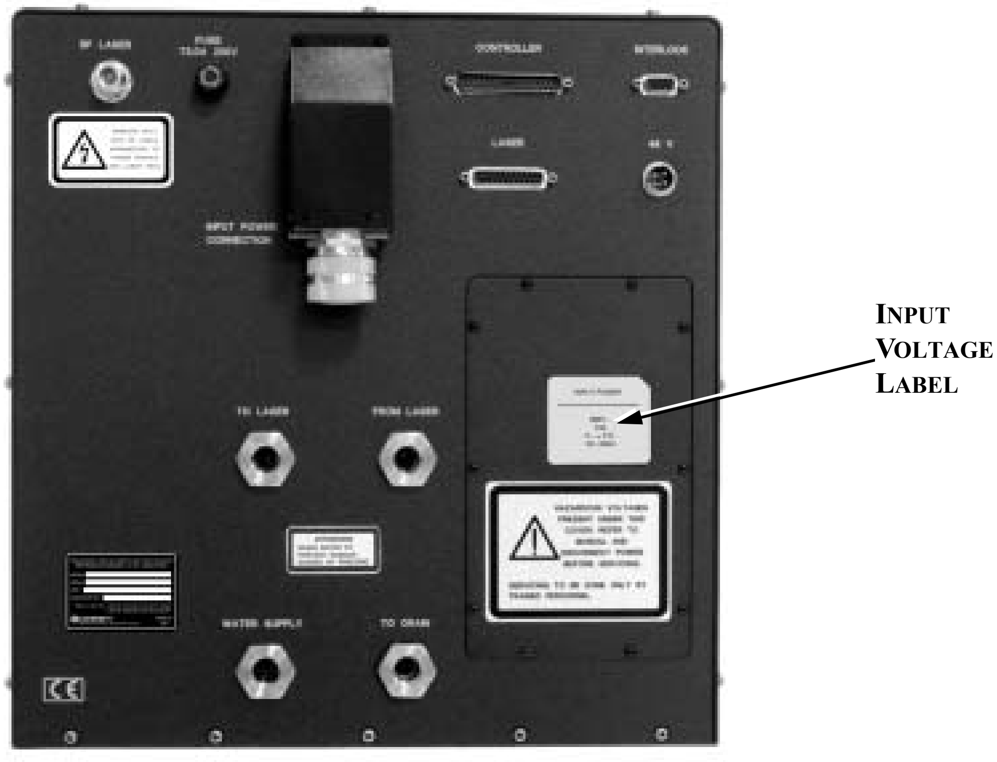


Figure 3-4. Input Voltage Range Label

should appear as shown in Figure 3-6. The correct input voltage label should now appear right side up and the incorrect input voltage range should be upside down.

6. Replace the cover over the voltage selection assembly with the yellow warning label oriented right side up. Tighten all 10 screws to retain the voltage selection assembly. The rear of the power module should appear as shown in Figure 3-4 except the correct input voltage label should be visible.
7. Check the input voltage range on the label to ensure that it is the same as the voltage of the facility input power. If these two values do not agree, check the facility input voltages available and check to make sure all the steps above have been followed correctly.

Connecting Input Power Wiring

This section describes the method of connecting the input power lines to the rear of the power module. It should be done only after the power module has been configured for the proper input voltage. In

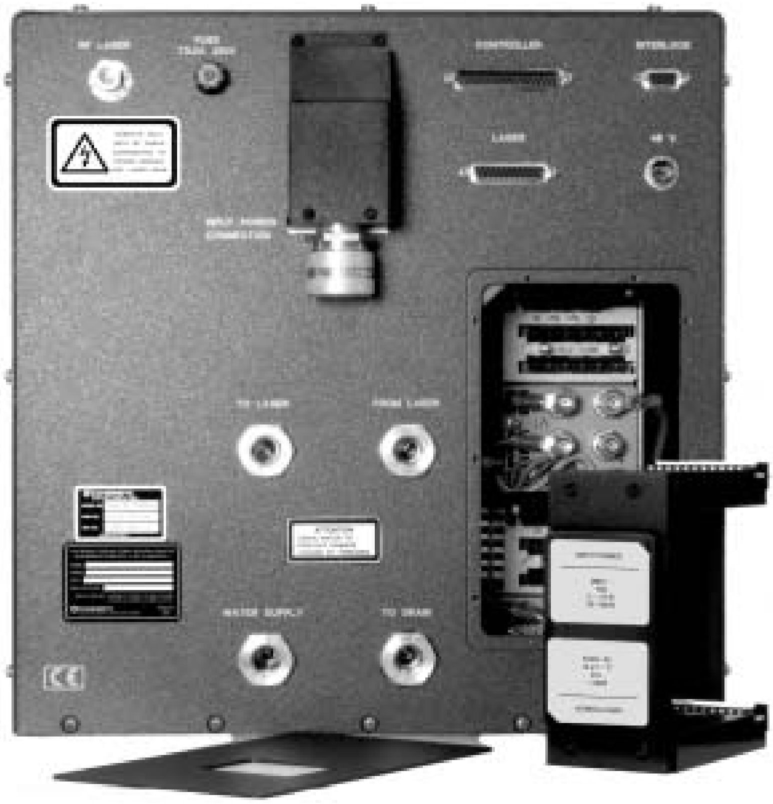


Figure 3-5. Input Voltage Selector Assembly (Removed)

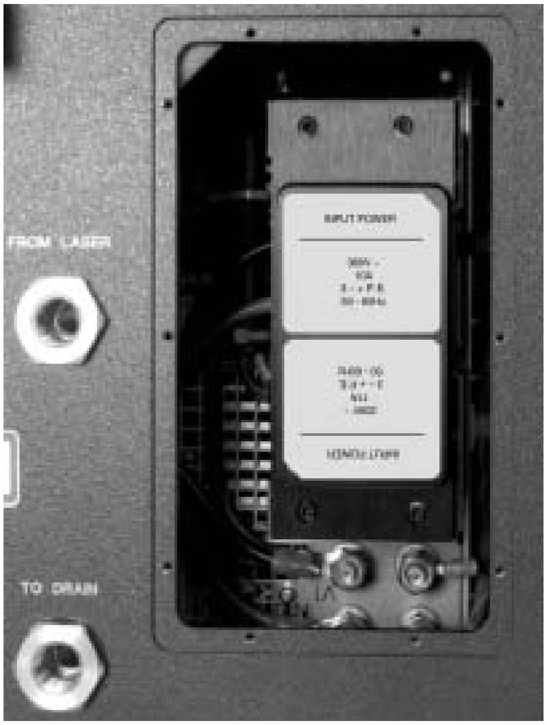


Figure 3-6. Input Voltage Selector Assembly (Installed)

the center of the power module is a terminal box with strain relief. See Table 3-3 for the proper wire size and switched fuse box or circuit breaker. A user supplied switch is required. See Figure 3-8 for laser system interconnection diagram.

To connect the wiring to the power module, remove the six screws retaining the cover over the input power terminals. Loosen the nut on the strain relief to have the largest opening for the wires. Strip the end of the wires approximately 1/4 inch (6 mm). Push the wires through the strain relief and attach the appropriate wires to the label terminals. Note that L1, L2, and L3 are for the three power lines while the protective earth conductive terminal is for the ground wire or protected earth connection. The phase rotation is not critical for the power module. Tighten the set screws to retain the wires in the terminals. Tighten the strain relief and replace the terminal cover with the six screws.

Interconnecting Electrical Cables

Refer to Figure 3-8, Laser System Interconnection Diagram, and connect the electrical cables as follows.

Ensure that all electrical connections are made according to the following paragraphs before the facility power is applied to the unit. Failure to do so can put expose operators to hazardous voltages.

Do not connect the power module to facility power until all electrical connections have been completed. Refer to Figure 4-8 through Figure 4-11 for the location of connectors referenced below.

The user must provide the wiring between the power module and the facility power. Refer to Table 3-3 for the correct wire size and recommended fuses or circuit breakers.

1. Ensure the main disconnect is in the off position. Also ensure the key switch on both the power module and remote control are in the off position.
2. Connect the DB37 cable between the power module connector labeled CONTROLLER and the remote control unit connector labeled INTERFACE. Tighten the two screws on each DB37 connector.
3. Connect the 4-pin cable between the power module connector labeled 48 V and the remote control unit connector labeled 48 VDC/PS J12 rear panel.

4. Connect DB25 cable between the power module connector labeled LASER and the laser head connector labeled CONTROL.
5. Connect the supplied RF cable between the laser head connector marked RF IN and the connector on the power module labeled RF LASER. Refer to Figure 4-10 for the location of the RF connector.

   The RF cable is available in various lengths to retain RF matching. No splicing or connectors are permitted.

   Use only the supplied RF cable for proper operation of the system.

RF Cable Installation and Options

The Diamond laser system is shipped with a high quality RF cable. The standard length of this cable is 10 feet and optional lengths are available to a length of 50 feet. The Diamond laser system must be operated with a cable assembly supplied by Coherent. Cutting or splicing of this cable will interfere with the proper operation of this system. The table below shows the appropriate part number for ordering a longer RF cable with the correct length of control cable and water hoses. The RF cables listed in the table have one straight connector and one 90° elbow male connector. Other combinations of all straight or all elbow connectors are available. Contact Coherent for full information regarding ordering an RF cable up to a length of 50 feet.

LENGTH (feet)	LENGTH (meters)	KIT PART NUMBER	NOTES
10	3	0165-771-10	3/8" ID water hose
20	6	0165-771-20	3/8" ID water hose
30	9	0165-771-30	1/2" ID water hose
40	12	0165-771-40	1/2" ID water hose
50	15	0165-771-50	1/2" ID water hose

In some applications using the Diamond laser, the RF cable must be repeatedly flexed. All RF cables supplied will withstand repeated flexures to a minimum bend radius of 2.8 inches (7 cm). When the application requires repeated flexing of the RF cable, substantially longer life is achieved if the bend radius is 30 times the cable diameter or larger. With proper handling and mounting, the RF cable assemblies will provide a long period of reliable service. The following practices must be followed to ensure the maximum performance and lifetime from the RF cable assembly.

Failure to observe the following practices may result in loss of warranty for the associated components.

---

1. Ensure that the RF cable connections are firmly tightened. With the standard cable assemblies firmly finger tight is sufficient. These connections should be checked approximately once per month. The recommended coupling torque is 15 inch lb. (1.7 Nm).
2. Use as large a bend radius as possible. Do not exceed the minimum bend radius of the cable. The minimum bend radius in a dynamic situation is 2.8 inches (7 cm).
3. If the cable needs to be clamped or restrained in some manner use a Neoprene cushioned cable clamp such as Richco SPNW series. Do not use a tie wrap. Distorting the cable cross section will cause a shortened cable life and failure.
4. When the cable must be suspended, use a steel cable to attach the RF cable to for support. The RF cable must not be used as a suspension cable for other control cables, water cooling lines, or exhaust ducts.
5. Cables that are repeatedly flexed should be inspected periodically over their total length for signs of wear. Replace the RF cable if the outer cover is cut or worn through to the braided layer.
6. Do not cross-thread the coupling nut.
7. Do not crimp or kink the cable.
8. Do not stand on the RF cable.
9. Do not place or drop heavy equipment on the RF cable.

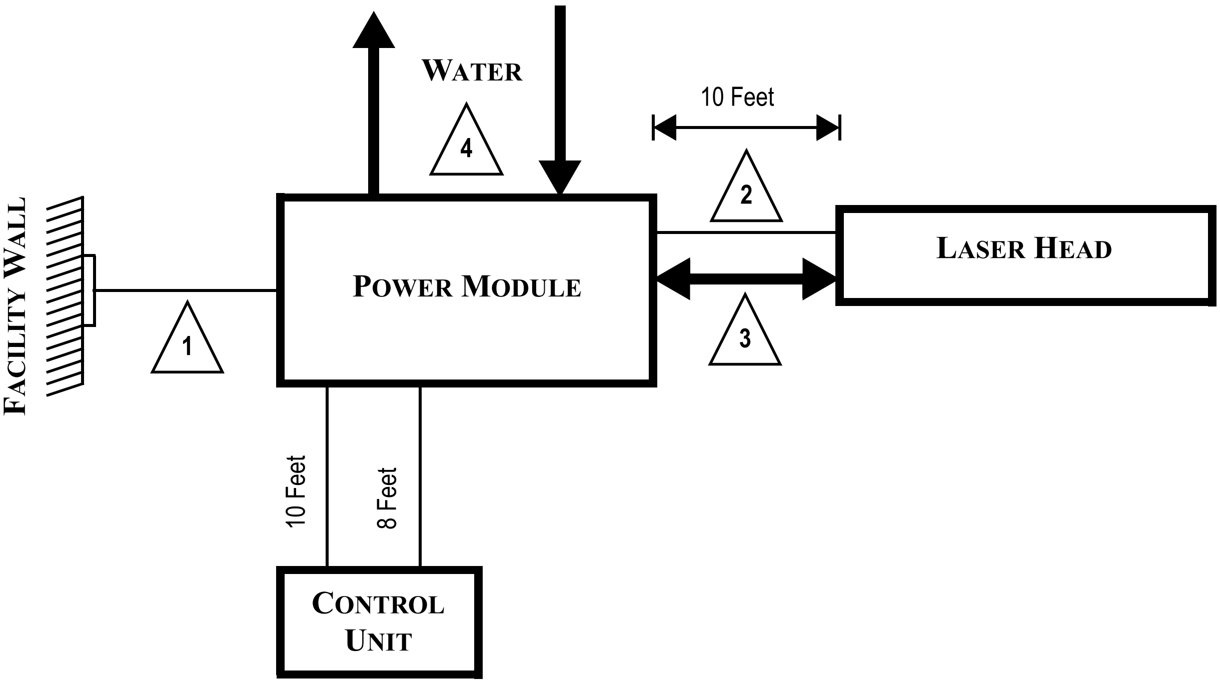
In most industrial equipment, the RF cable will be placed alongside of other cables such as control cables and also the water cooling lines. It should be noted that the external temperature of a single RF cable in air operates at temperatures of approximately 60°C (140°F) or a temperature rise of about 35°C (63°F) above the ambient temperature. The stable operating temperature of the cable will be determined by the cables surrounding the RF cable and the average duty cycle of the laser. Make sure that the other cable assemblies in contact with the RF cable are insulated with material that is rated for the elevated operating temperatures.

Water Line Connections

Refer to Figure 3-8 for the interconnection diagram. Refer to Figure 4-8 and Figure 4-9 for the location of laser head and power module water hose connectors.

The cooling water source can be facility water or a closed-loop cooling system. If facility water is used, ensure that the water meets the requirements listed in Table 3-3. Refer to the paragraph titled Cooling Water (located in this chapter) for additional information.

1. Connect the 3/8" ID nylon reinforced PVC water hose from the water source to the power module water hose connector labeled WATER SUPPLY. Fittings with hose barbs are provided for use of a hose without attached fittings. Alternatively, if a garden hose is used, the appropriate fittings are provided. Use the Teflon tape as a thread seal for these fittings.
2. Connect a nylon reinforced PVC water hose from the power module water hose connector labeled DRAIN to the facility water drain. Use the hose barb fittings provided on both the laser head and power module.
3. Connect a nylon reinforced PVC water hose from the power module water hose connector labeled TO LASER to the water connector on the laser head labeled WATER IN. Use the hose barb fittings provided on both the laser head and power module.
4. Connect a nylon reinforced PVC water hose from the power module water hose connector labeled FROM LASER to the water connector on the laser head labeled WATER OUT.
5. Verify that there are no water leaks as follows:
    - Open the valve in the water drain line.
    - Slowly open the valve in the water supply line.
    - With the water supply pressure and water line differential pressure in accordance with Table 3-3, check all connections for leaks.



1 The customer must provide input power cable. See Table 3-1 for recommended wire size.

2 The RF cable is available in additional increments to retain RF matching. No splicing or connectors are permitted.

3 This is a standard 10 foot cable with DB25 connectors and can be extended up to 50 feet (15 m) with optional cables. Note that RF cabling and cooling water lines will be the same length.

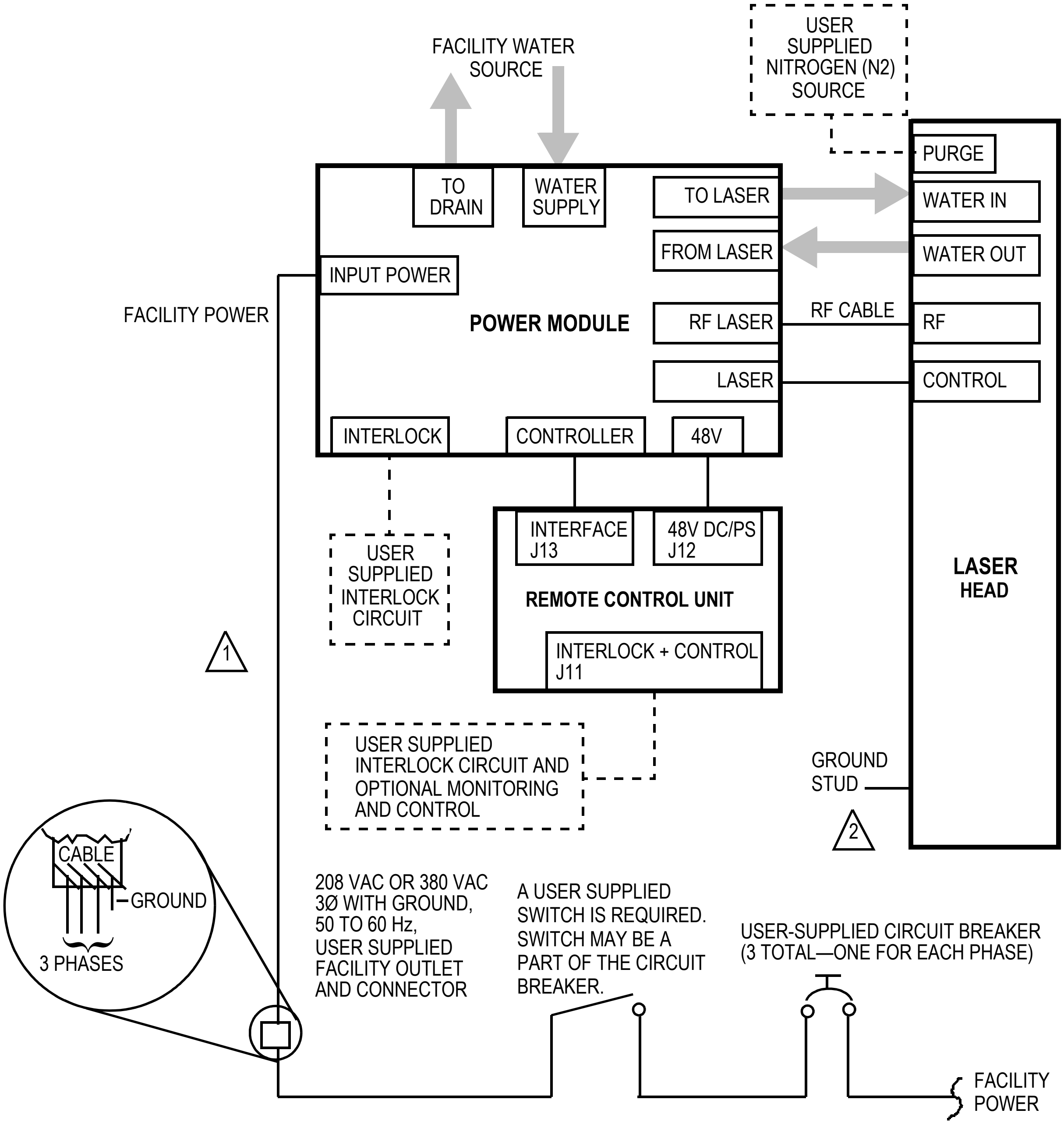
4 Water lines can be any length as long as the pressure requirements listed in Table 3-3 are met.

Figure 3-7. Mounting Distances Diagram

External Safety Interlock

The Diamond is shipped with a plug installed on the INTERLOCK connector on the remote control unit rear panel. This plug shorts pins 14 and 15. The Diamond will not operate with this plug removed (pins 14 and 15 open circuit).

A safety interlock circuit can be wired to this connector that will automatically turn the laser off. The safety interlock circuit needs to provide an open circuit across pins 14 and 15 to shut down the laser and a closed circuit to allow operation. This interlock operates from +5 VDC supplied by the DC power supply located in the power module.


USER SUPPLIED NITROGEN (N2) SOURCE
FACILITY WATER SOURCE
PURGE
TO DRAIN
WATER SUPPLY
TO LASER
WATER IN
FROM LASER
WATER OUT
INPUT POWER
FACILITY POWER
POWER MODULE
RF LASER
RF CABLE
RF
LASER
CONTROL
INTERLOCK
CONTROLLER
48V
INTERFACE J13
48V DC/PS J12
LASER HEAD
USER SUPPLIED INTERLOCK CIRCUIT
REMOTE CONTROL UNIT
1
INTERLOCK + CONTROL J11
USER SUPPLIED INTERLOCK CIRCUIT AND OPTIONAL MONITORING AND CONTROL
GROUND STUD
2
CABLE
GROUND
3 PHASES
208 VAC OR 380 VAC 3Ø WITH GROUND, 50 TO 60 Hz, USER SUPPLIED FACILITY OUTLET AND CONNECTOR
A USER SUPPLIED SWITCH IS REQUIRED. SWITCH MAY BE A PART OF THE CIRCUIT BREAKER.
USER-SUPPLIED CIRCUIT BREAKER (3 TOTAL—ONE FOR EACH PHASE)
FACILITY POWER

1 USER SUPPLIED WIRING

2 CONNECT GROUND STUD TO PROTECTIVE EARTH GROUND. USE 12 AWG WIRE SIZE (MINIMUM). MAXIMUM LENGTH 60 INCHES (1.5 METERS). REFERENCE FIGURE 4-8 AND TABLE 4-5 ITEM 6.

NOTE: DASHED LINES INDICATE AN OPTIONAL ITEM.

Figure 3-8. Laser System Interconnection Diagram

A second safety interlock connector is located on the power module rear panel and labeled INTERLOCK. If this connector is used in the interlock circuit, use pins 4 and 8. The operation is identical to the function of the interlock connector on the remote control unit including the operating voltage.

Turning on the Laser

Before turning on the laser system for the first time:

1. Unscrew the shipping plug from the output aperture on laser head front panel.
2. Place a beam block or power meter in front of the output aperture.
3. Ensure the facility circuit breaker and the facility On/Off switch are set to Off.
4. Connect the power module power cable to the facility wall outlet.
5. Ensure the ON/OFF keyswitch on the power module is turned OFF.

Ensure all personnel in the area are wearing laser safety glasses appropriate for the CO_2 laser and power levels produced.

Refer to Chapter Five, Maintenance and Troubleshooting, to resolve any faults or problems encountered during startup.

Before proceeding, ensure all safety practices are in effect including those in Chapter Two, Laser Safety, of this manual, and that the laser is directed in a safe manner so that the output beam will not strike an unintended target.

6. Turn on the laser system cooling water. To avoid over-pressurization of the cooling system, open the drain valve before opening the supply valve.
7. Ensure controls on the remote control unit are set according to Table 3-5.
8. Ensure the EMERGENCY STOP switch on the power module is turned clockwise to the ON position.

9. Turn on the remote control unit keyswitch. Turn on the power module keyswitch. The following should occur:

    - The ON indicator on the power module turns on.

      The green EMISSION indicator on the remote control unit turns on.

      The white LASER EMISSION indicator on the front of the laser head turns on.

    - A delay of approximately 10 seconds begins.
    - The RF GATE indicator turns on.
    - The amber DELAY indicator on the power module flashes on and off indicating the system delay of approximately 10 seconds is in process.
    - The DELAY indicator stops flashing and the green READY indicators turn on indicating the system is ready for use. READY indicators are located on both the power module and on the remote control unit.

The status of the following indicators should be Off. If not, refer to Table 5-1.

POWER MODULE

SHUTTER OPEN
SHUTTER FAULT
HEAD THERMAL
VSWR
REFLECTED
DELAY
HEAD COVER
WATER FLOW
DUTY CYCLE
FORWARD

REMOTE CONTROL UNIT

FAULT
MODULATION ON
SHUTTER OPEN

10. Set the AIMING BEAM switch to ON. The aiming beam is visible with the shutter closed. Point the laser at the desired target.

11. Open the shutter by setting the SHUTTER OPEN/ CLOSE switch to OPEN.

12. Turn on modulation, by setting the MODULATION CONTINUOUS/OFF/MOMENTARY switch to either CONTINUOUS or MOMENTARY.

Table 3-5. Remote Control Unit Settings for Laser Startup

INDEX	SWITCH	POSITION
1.	PULSE PERIOD µS	6000 µsec. A 6000 µsec pulse period in combination with a 200 µsec pulse width is recommended for initial startup. This combination should result in 25 to 30 Watts output power. Note that the thumbwheel switches are inactive if the MOD SELECT switch is set to EXT.
2.	PULSE WIDTH µS	200 µsec. A 200 µsec pulse width in combination with a 6000 µsec pulse period is recommended for initial startup. This combination should result in 25 to 30 Watts output power. Note that the thumbwheel switches are inactive if the MOD SELECT switch is set to EXT.
9.	SHUTTER REMOTE/LOCAL	LOCAL if using the remote control unit only to control the shutter position. REMOTE if using an external device connected to the REMOTE SHUTTER SWITCH J15 connector on the remote control unit rear panel to control the shutter position.
10.	MODULATION ENABLE	LOCAL if the laser on and off condition is to be controlled by the MODULATION CONTINUOUS/OFF/MOMENTARY switch. REMOTE if the laser on and off condition is to be controlled by a connection at the REMOTE MODULATION SWITCH connector on the rear panel.
11.	Keyswitch	OFF (on the remote control unit and on the power module)
13.	MOD SELECT switch	LOCAL if the PULSE PERIOD µS and the PULSE WIDTH µS thumbwheel switches will be used to control laser power. EXT for controlling laser power using an external signal generator connected to the EXT PULSE GEN J6 connector on the rear panel. PW Δ for controlling laser power by varying the pulse width at a constant pulse period. PP Δ for controlling laser power by varying the pulse period at constant pulse width.
14.	AIMING BEAM	OFF
15.	SHUTTER OPEN/CLOSE	CLOSE if the remote control unit is used to control the shutter. If the shutter will be controlled by an external device, use the external device to close the shutter after setting the SHUTTER REMOTE/LOCAL switch to REMOTE. The SHUTTER OPEN/CLOSE switch is disabled when the SHUTTER REMOTE/LOCAL switch is set to REMOTE.
16.	MODULATION CONTINUOUS/ OFF/MOMENTARY	OFF. This switch is active only when the MOD ENABLE switch is in the LOCAL position.
The index numbers in this table correspond to the index numbers on Figure 4-11.		

OPERATOR'S MANUAL

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CHAPTER FOUR
DAILY OPERATION

Introduction

This chapter provides operating procedures and a description of the Diamond controls, indicators, and interface connectors.

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Operation

Operation consists of performing the startup procedures in the following sections. Since operation is dependent on the laser configuration, the following topics are included as part of operation:

- Operating configurations – lists common laser system configurations (Table 4-1) and the associated switch settings (Table 4-2) to implement the steps listed under operating sequence.
- Operating notes – summarizes some of the key operating features.
- Examples – provides step-by-step procedures for implementation of the operating sequence for several operating configurations.
- Adjusting the Diamond output – describes operating range for performance optimization.

Startup Procedure

Ensure all personnel in the area are wearing laser safety glasses appropriate for the CO_2 laser and power levels produced.

Refer to Chapter Five, Maintenance and Troubleshooting, to resolve any faults or problems encountered during startup.

Before proceeding, ensure all safety practices are in effect including those in Chapter Two, Laser Safety, of this manual, and that the laser is directed in a safe manner so that the output beam will not strike an unintended target.

1. Ensure the beam will not strike an unintended target.
2. Ensure the shutter is closed.
3. Turn on the laser system cooling water. To avoid over-pressurization of the cooling system, open the drain valve before opening the supply valve.
4. Ensure the EMERGENCY STOP switch on the power module is turned clockwise to the ON position.
5. Turn on the facility circuit breaker and facility On/Off power switch (if installed).
6. Turn on the remote control unit keyswitch. Turn on the power module keyswitch. The following should occur:
    - The ON indicator on the power module turns on.

      The green EMISSION indicator on the remote control unit turns on.

      The white LASER EMISSION indicator on the front of the laser head turns on.
    - A delay of approximately 10 seconds begins.
    - The RF GATE indicator turns on.
    - The amber DELAY indicator on the power module flashes on and off indicating the system delay of approximately 10 seconds is in process.
    - The DELAY indicator stops flashing and the green READY indicators turn on indicating the system is ready for use. READY indicators are located on both the power module and on the remote control unit.

The status of the following indicators should be Off. If not, refer to Table 5-1.

POWER MODULE

SHUTTER OPEN
SHUTTER FAULT
HEAD THERMAL
VSWR
REFLECTED
DELAY
HEAD COVER
WATER FLOW
DUTY CYCLE
FORWARD

REMOTE CONTROL UNIT

FAULT
MODULATION ON
SHUTTER OPEN

7. Set the AIMING BEAM switch to ON. The aiming beam is visible with the shutter closed. Point the laser at the desired target.

8. Open the shutter by moving the switch labeled SHUTTER OPEN/CLOSE to the OPEN position.
9. Turn on modulation. There are several ways to apply modulation as described in Table 4-1, Operating Configurations, and Table 4-2, Operating Configurations Switch Settings.

   Alternately, the startup procedures located in Chapter Three can also be used.

Operating Configurations

Standard Diamond operating configurations are summarized in Table 4-1. Table 4-2 lists the switch settings associated with the operating configurations. Modulation must be off when switch settings on the remote control unit are changed, with the exception of the ΔADJ knob. Refer to Figure 4-11 and Table 4-3 for a description of the ΔADJ knob.

Operating Notes

The following notes may be helpful in understanding the operation of the Diamond laser.

Indicators

The green indicators on the power module and remote control will be lit when the system is turned on and ready for operation. The white emission indicator light on the laser head will be lit when the system is turned on.

The red indicators on the power module show that there is a fault and the system cannot be operated.

The amber indicators on the power module show a warning condition. As an example, when the shutter opens the SHUTTER SENSE indicator will turn on showing that this process has been completed and that laser power can reach the work area. The other amber indicators (VSWR, DUTY CYCLE, REFLECTED, and FORWARD) register conditions that are not typical but will not harm the condition of the laser system. These conditions are typically momentary events in time that are indicated only when the fault is active.

Changing Operating Parameters

With the exception of the ΔADJ knob, any change to the PULSE PERIOD and PULSE WIDTH thumbwheel switches on the remote control unit will be ignored while modulation is turned on. Modulation must be off for these changes to be recognized.

Table 4-1. Operating Configurations

MODE #	DESCRIPTION
1.	Using the PULSE PERIOD µs and PULSE WIDTH µs thumbwheel switches to control output power. The On/Off state of the laser is controlled by the MODULATION CONTINUOUS/ OFF/MOMENTARY switch on the remote control unit front panel.
1a.	Same as mode 1 except the On/Off state of the laser is controlled by an external device connected to the REMOTE MODULATION SWITCH connector on the remote control unit rear panel.
2.	Using either the PWΔ or the PPΔ switch position (MOD SELECT switch) in conjunction with the Δ ADJ control knob to control modulation and output power. The On/Off state of the laser is controlled by the MODULATION CONTINUOUS/ OFF/MOMENTARY switch on the remote control unit front panel.
2a.	Same as 2 except the On/Off state of the laser is controlled by an external device connected to the REMOTE MODULATION SWITCH connector on the remote control unit rear panel.
2b	Same as 2 except the power level is controlled by an external device connected to the ANALOG INPUT connector on the remote control unit rear panel. The On/Off state of the laser is controlled by the MODULATION CONTINUOUS/ OFF/MOMENTARY switch on the remote control unit front panel.
2c.	Same as 2 except the power level is controlled by an external device connected to the ANALOG INPUT connector on the remote control unit rear panel. The On/Off state of the laser is controlled by an external device connected to the REMOTE MODULATION SWITCH connector on the remote control unit rear panel.
3.	Using an external pulse generator connected to the EXT PULSE GEN connector on the remote control unit rear panel as the source of modulation. The On/Off state of the laser is controlled by the MODULATION CONTINUOUS/ OFF/MOMENTARY switch on the remote control unit front panel.
3a.	Same as 3 except the On/Off state of the laser is controlled by an external device connected to the REMOTE MODULATION SWITCH connector on the remote control unit rear panel.
4.	Using an external gating device connected to the MODULATION GATE connector on the remote control unit rear panel as an additional gating control. The operation using MODULATION GATE is in parallel to the other functions noted above in modes 1 through 3.
5.	Using an external device interfaced directly to the CONTROLLER input on the power module. Refer to Appendix A for information on operating in this mode.
The mode #s in Table 4-1 correspond to the mode #s in Table 4-2.	

Selecting the Source for Pulse Parameters

Setting the MOD SELECT switch to EXT selects an external device such as a pulse generator to determine the pulse parameters. Setting the MOD SELECT switch to any position other than EXT selects the remote control unit for pulse parameters.

Table 4-2. Operating Configurations Switch Settings

MODE #	SWITCH POSITION				
	PULSE PERIOD/ PULSE WIDTH THUMBWHEEL	MOD ENABLE	ΔADJ	MODULATION CONTINUOUS/ OFF/MOMENTARY	MOD SELECT
1.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Note 1	LOCAL	Inactive	Active Refer to Note 2	LOCAL
1a.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Note 1	REMOTE	Inactive	Inactive	LOCAL
2.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Note 1	LOCAL	Active (not in Off position) Refer to Note 2	Active Refer to Note 2	PWΔ or PPΔ
2a.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Note 1	REMOTE	Active (not in Off position) Refer to Note 2	Inactive	PWΔ or PPΔ
2b.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Note 1	LOCAL	Off - fully CCW	Active Refer to Note 2	PWΔ or PPΔ
2c.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Note 1	REMOTE	Off - fully CCW	Inactive	PWΔ or PPΔ
3.	Inactive	LOCAL	Inactive	Active Refer to Note 2	EXT
3a.	Inactive	REMOTE	Inactive	Inactive	EXT
4.	**PULSE PERIOD**: 6000 **PULSE WIDTH**: 200 Refer to Notes 1 and 4)	LOCAL	Inactive	Active Refer to Note 2	LOCAL

NOTES:

1. A 200 µsec pulse width in combination with a 6000 µsec pulse period is recommended for initial startup. This combination should result in 25 to 30 Watts output power.
2. This switch performs the normal functions as described in Table 4-7.
3. The mode #s in Table 4-1 correspond to the mode #s in Table 4-2.
4. This is an example using MODULATION GATE as in mode #1 and all other modes are possible.

Modulating the Laser

Applying modulation to the RF amplifier (located in the power module) causes the laser to turn on. Application of modulation controls the On/Off state of the laser. Once the modulation source has been selected as described in this paragraph, modulation can be applied to the laser.

Setting the MOD ENABLE switch to REMOTE allows an external device connected to the REMOTE MODULATION SWITCH connector on the remote control unit rear panel to control the application of modulation.

Setting the MOD ENABLE switch to LOCAL allows the MODULATION CONTINUOUS/OFF/MOMENTARY switch to control the application of modulation.

The MODULATION GATE provides an additional input to control the laser modulation.

The position of the MOD ENABLE switch is recognized even when providing the proper inputs at the MODULATION GATE. Thus, if the MOD ENABLE switch is in the LOCAL position, then laser will be turned on only when both the MODULATION CONTINUOUS/OFF/MOMENTARY switch is in either the CONTINUOUS or MOMENTARY position and the input at the MODULATION GATE is at TTL low (approximately 0 VDC).

To turn the laser modulation to the Off state, either the MODULATION GATE must be switched to a TTL high (or approximately +5 VDC) or the MODULATION CONTINUOUS/OFF/ MOMENTARY switch must be set to the OFF position.

Adjusting the Diamond Output

The Diamond can operate using various pulse formats which allows full user control of the output depending on the application. Parameters that can be controlled by the operator that affect the output include:

- Pulse period 10 µs minimum (or pulse frequency 100 kHz maximum)
- Pulse width (4 µsec to 1000 µsec)

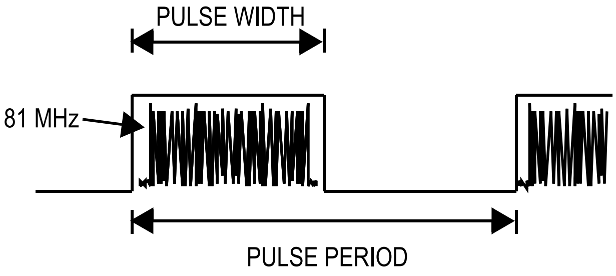
Varying one or more of these parameters impacts the following output characteristics:

- Average output power
- Peak pulse power (pulse energy)
- Duty cycle (range: 0% to 60%)

The total number of possible input parameter variations and the resulting output is quite large. The following discussion provide graphs and examples of many of the possibilities:

A graphical definition of the pulse width is shown in Figure 4-1. During the time interval of the pulse width, the RF power is directed to the laser head. In the Diamond laser system, the RF frequency is 81 MHz. The pulse width is the time that the RF is turned on and the pulse period is the time between the leading edges of these repetitive pulses. Another way to describe the pulse period is the pulse frequency which is just the inverse of the pulse period. A pulse period of 1,000 µs corresponds to an operating frequency of 1000 Hz.

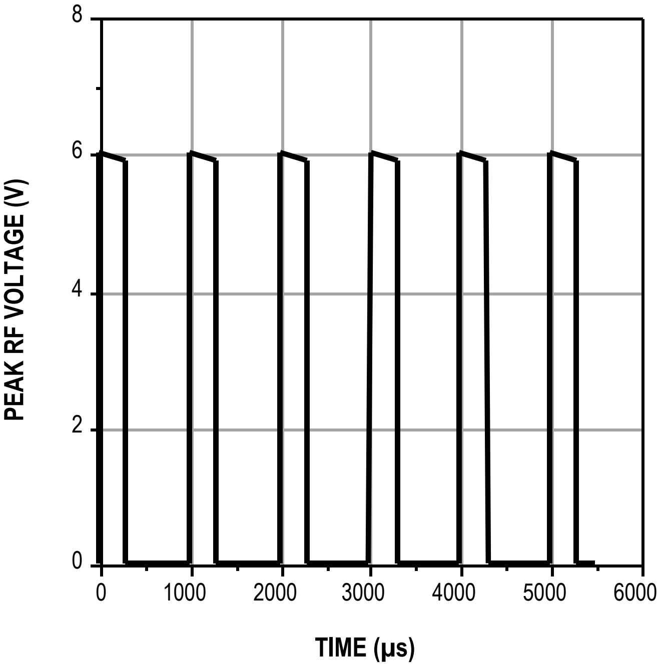
In order to have an efficient laser, all the power that is developed by the RF amplifier (located in the power module) must be delivered to the laser tube. In practice, over 95% of the power that is developed by the RF amplifier is delivered to the laser tube and the remaining power is reflected back toward the RF power supply. The waveforms of the forward RF voltage directed to the tube and then reflected are shown in Figure 4-2. These parameters are important in the function of the Diamond laser system and they have several related warning indicators on the front panel of the power module.



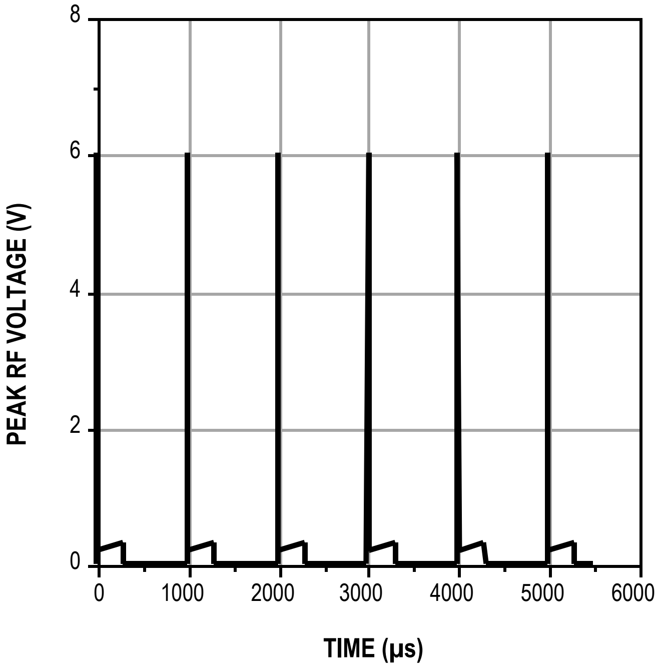
$$\text{DUTY CYCLE} = \frac{\text{PULSE WIDTH}}{\text{PULSE PERIOD}} \times 100\%$$

Figure 4-1. Typical Pulse/Modulation

The FORWARD indicator will be activated when the forward RF voltage drops below approximately 70% of the typical value. The REFLECTED indicator is activated when the reflected voltage increase by a factor of 2 (approximately) above the typical maximum value. The VSWR indicator becomes active when the ratio of the reflected and forward increases above a safe level.



A. FORWARD RF



PULSE WIDTH = 300 µs
PULSE PERIOD = 1000 µs

B. REFLECTED RF

Figure 4-2. Diamond Laser Tube Forward and Reflected Voltage Waveforms

Table 4-3. Using the PW∆, PP∆, and ∆ADJ Switches to Control Output Power

The following method gives an example of how to use the PWΔ function in conjunction with the ΔADJ knob to set up a processing operation or a specific laser power. It goes on to automating this process using the ANALOG INPUT function on the rear panel of the remote control unit. A similar method can be used for the PPΔ mode but initially selecting a PULSE WIDTH rather than a PULSE PERIOD.

1. Place a laser power meter or the material that must be processed into the beam path. Close the shutter and turn on the aiming beam to ensure that the material is properly positioned.

2. Select the PWΔ position of the MOD SELECT switch.

3. Select the operating PULSE PERIOD using the thumbwheel position. For this example choose a value of 1000 µs for an operating frequency of 1000 Hz.

4. Turn the ΔADJ knob clockwise so that it is not at the full CCW position. Select a position that is about 1/4 of a turn clockwise from the full CCW position.

5. Open the shutter. Using the remote control unit, toggle the SHUTTER OPEN/CLOSED switch to the OPEN position.

6. Turn the MODULATION on. Using the remote control unit, toggle the switch labelled MODULATION CONTINUOUS/OFF/MOMENTARY to the CONTINUOUS position.

7. Watching the material or the laser power meter, turn the ΔADJ knob clockwise to increase the power. The laser power will increase proportionally to this knob position. Select a position of the ΔADJ knob for the desired process effect or laser power.

8. Turn off the laser power by putting the MODULATION CONTINUOUS/OFF/MOMENTARY switch to the OFF position.

9. Place a power meter into the optical path but not at the focal point of any beam delivery optics. Measure the output power with the laser turned On.

   An alternate method is to close the laser shutter and connect an oscilloscope to the connector labelled SCOPE on the rear panel of the remote control unit. When the laser is turned on, a series of pulses can be seen at the SCOPE output. When the signal is at +5 V, the laser is on and off when it is a about 0 V. The operating pulse width will be the time that one pulse is at +5 V. Determine the operating pulse width for the desired output power.

10. Connect a source of DC voltage that is adjustable between 0 and +10 V to the ANALOG INPUT on the rear panel of the remote control unit. Initially adjust the voltage to read about 0.25 V.

11. Rotate the ΔADJ knob fully CCW.

12. Turn on the laser by putting the MODULATION CONTINUOUS/OFF/MOMENTARY switch to the CONTINUOUS POSITION. The shutter should be left in the closed position.

13. Slowly adjust the voltage source connected to ANALOG INPUT to achieve the same output power or pulse width as determined in step 10.

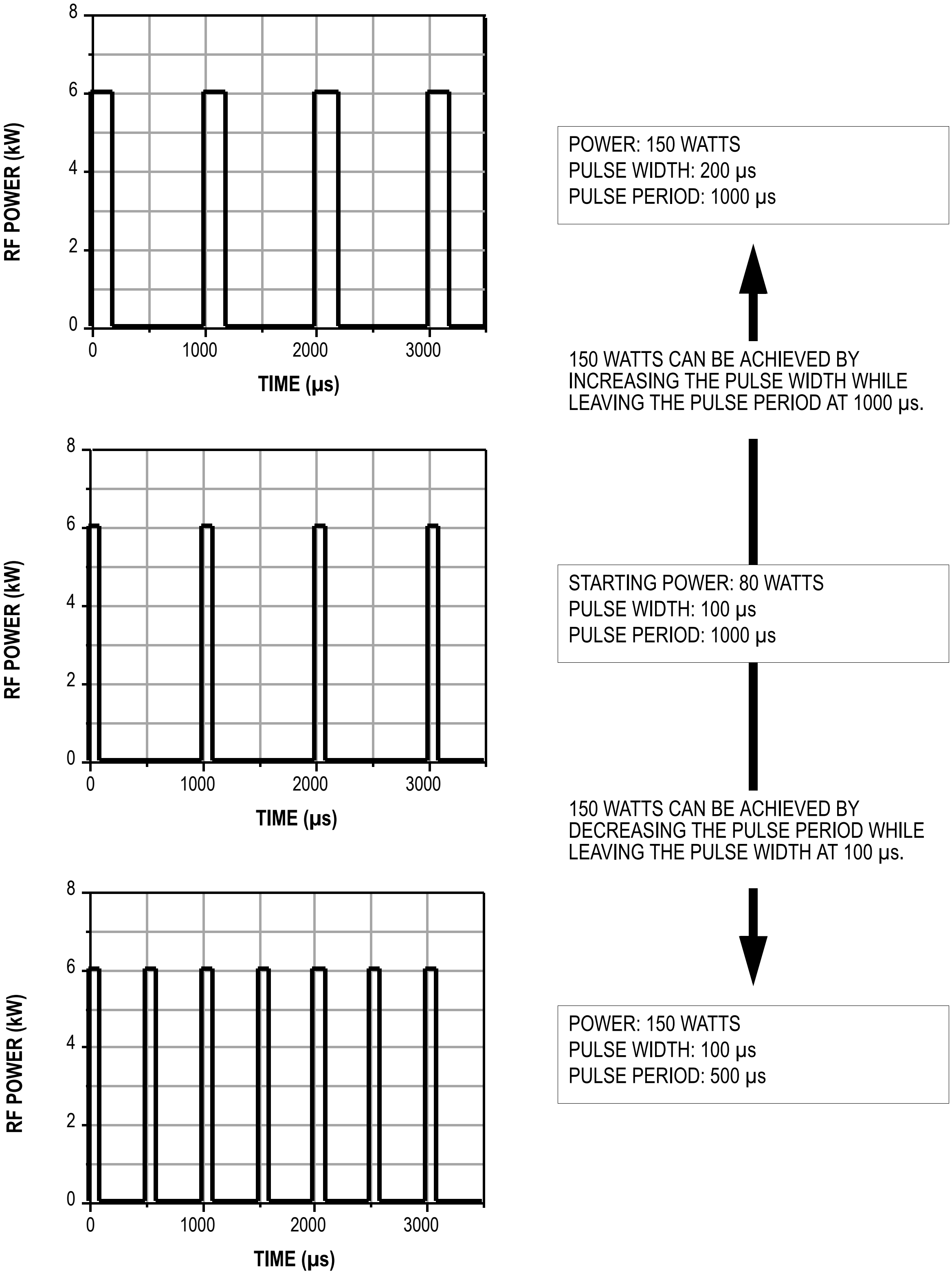
14. Open the shutter by toggling the SHUTTER OPEN/CLOSED switch to the OPEN position. Verify the correct laser power by monitoring the process on the material or by determining the laser power with a power meter.

In order to adjust the laser power, two different alternatives are possible and these are shown in Figure 4-3. The center illustration shows the starting condition with a 100 µs pulse width, a pulse period of 1000 µs and a typical output of about 80 W. One method to increase the laser power is to increase the pulse width and leave the pulse period the same. This is illustrated in the top trace in Figure 4-3. Under these conditions the pulse width has been increased to 200 µs and the output power has increased to about 150 W. The other method to increase the laser power, is to decrease the pulse period while leaving the pulse width the same. The lower trace of Figure 4-3 shows the reduced pulse period of 500 µs and the same pulse width of 100 µs. The output power would increase to about 150 W.

The full range of operation of the laser is illustrated in Figure 4-4. This shows the output power for different pulse widths. Each curve in these plots represents different pulse periods. Changing the pulse width has the effect of moving along one of the lines labeled with a pulse period. Changing the pulse period has the effect of moving vertically on this chart.

Pulsing the laser creates pressure gradients in the gases inside the laser. These gradients are subject to acoustic effects. Figure 4-4 shows a dip in the trend of power output verses frequency at around 5000 hertz. This is due to a resonant frequency excited by the energy in the RF discharge.

There are a large number of pulse widths and pulse periods that can deliver the same output power. The correct pulse parameters depend on the specific application. Often the effective speed of the beam on the sample will determine the desired pulse period. As the speed increases, then the pulse period will need to be decreased. Other factors such as edge finish can also be important in selecting both the pulse parameters and the average operating power for a specific process. As the pulse width is varied, there are also effects on the peak power available from the laser. The range of the peak power is illustrated in Figure 4-6. Generally, the peak power increases as the duty cycle decreases.



POWER: 150 WATTS
PULSE WIDTH: 200 µs
PULSE PERIOD: 1000 µs

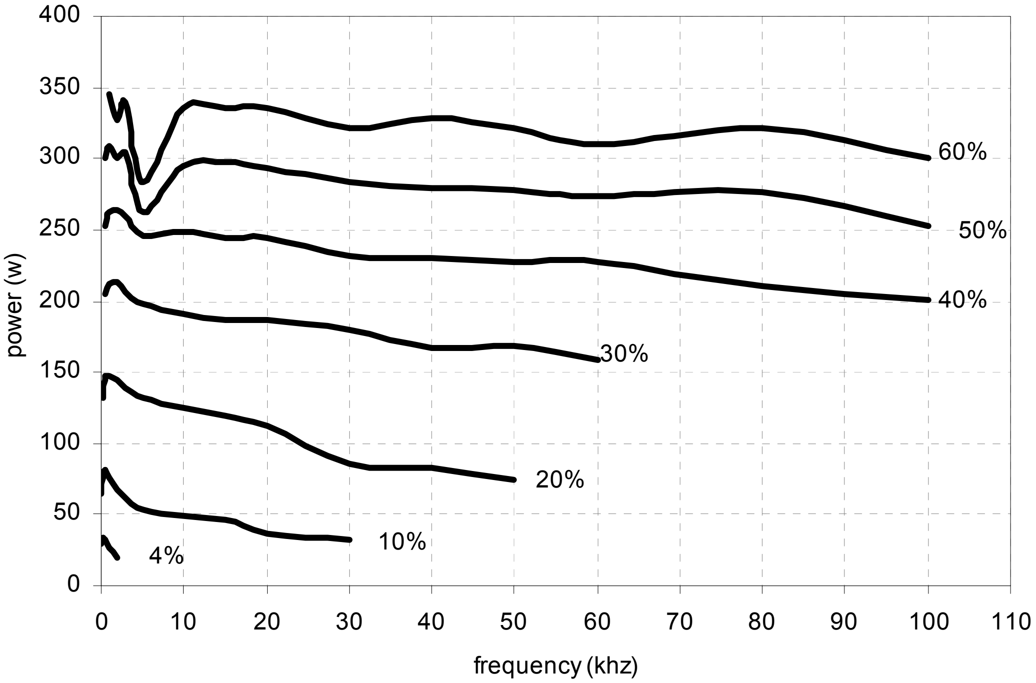
150 WATTS CAN BE ACHIEVED BY INCREASING THE PULSE WIDTH WHILE LEAVING THE PULSE PERIOD AT 1000 µs.

STARTING POWER: 80 WATTS
PULSE WIDTH: 100 µs
PULSE PERIOD: 1000 µs

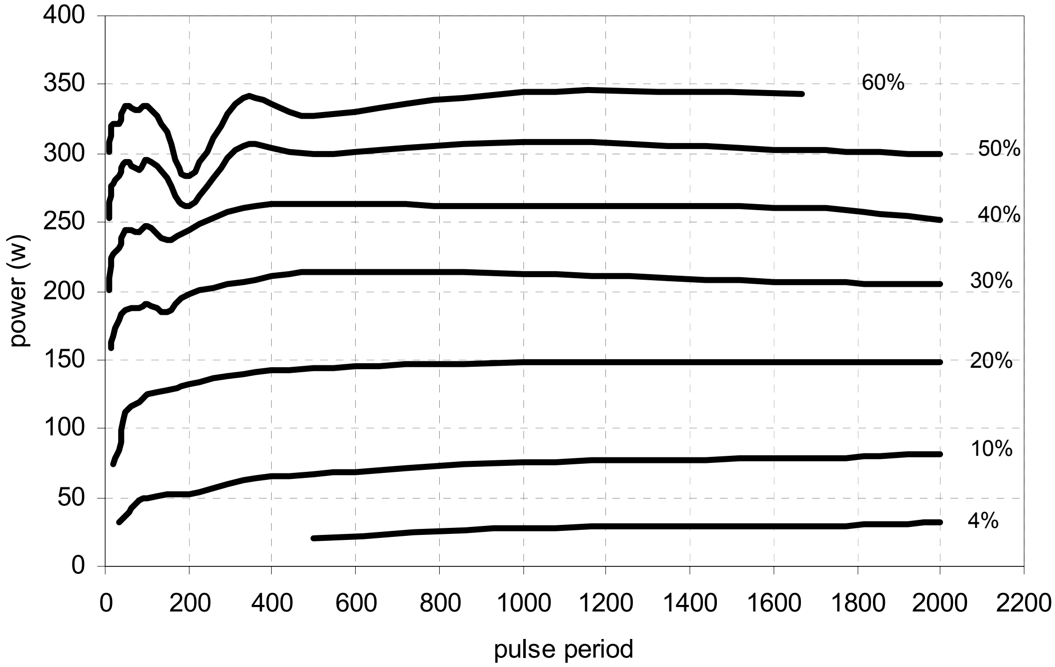
150 WATTS CAN BE ACHIEVED BY DECREASING THE PULSE PERIOD WHILE LEAVING THE PULSE WIDTH AT 100 µs.

POWER: 150 WATTS
PULSE WIDTH: 100 µs
PULSE PERIOD: 500 µs

Figure 4-3. Example of Changing Laser Power



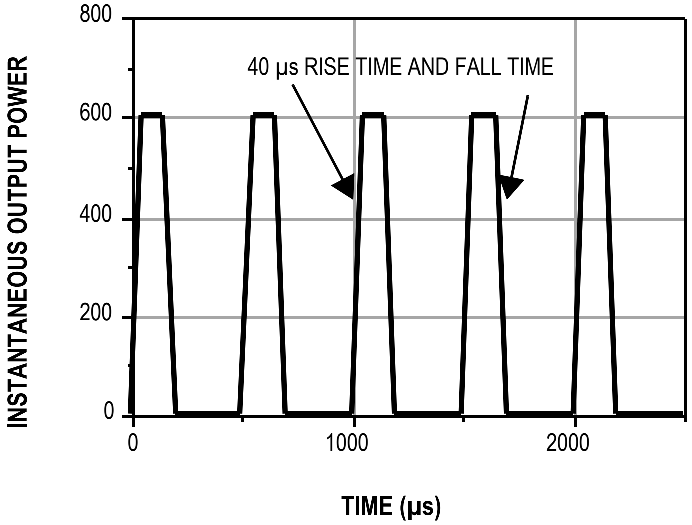
A. OUTPUT POWER AS FUNCTION OF PULSE PERIOD DURATION.
DUTY CYCLE IS NOTED FOR EACH CURVE.



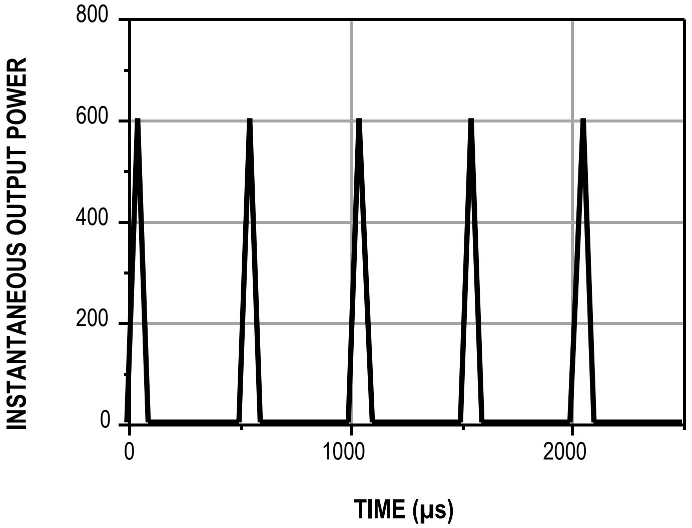
B. OUTPUT POWER AS FUNCTION OF OPERATING FREQUENCY.
DUTY CYCLE IS NOTED FOR EACH CURVE.

Note: Each curve represents the pulse period.

Figure 4-4. Typical Diamond K-300 Laser Output Power



A. PULSE WIDTH: 200 µS, PULSE PERIOD: 500 µS



B. PULSE WIDTH: 50 µS, PULSE PERIOD: 500 µS

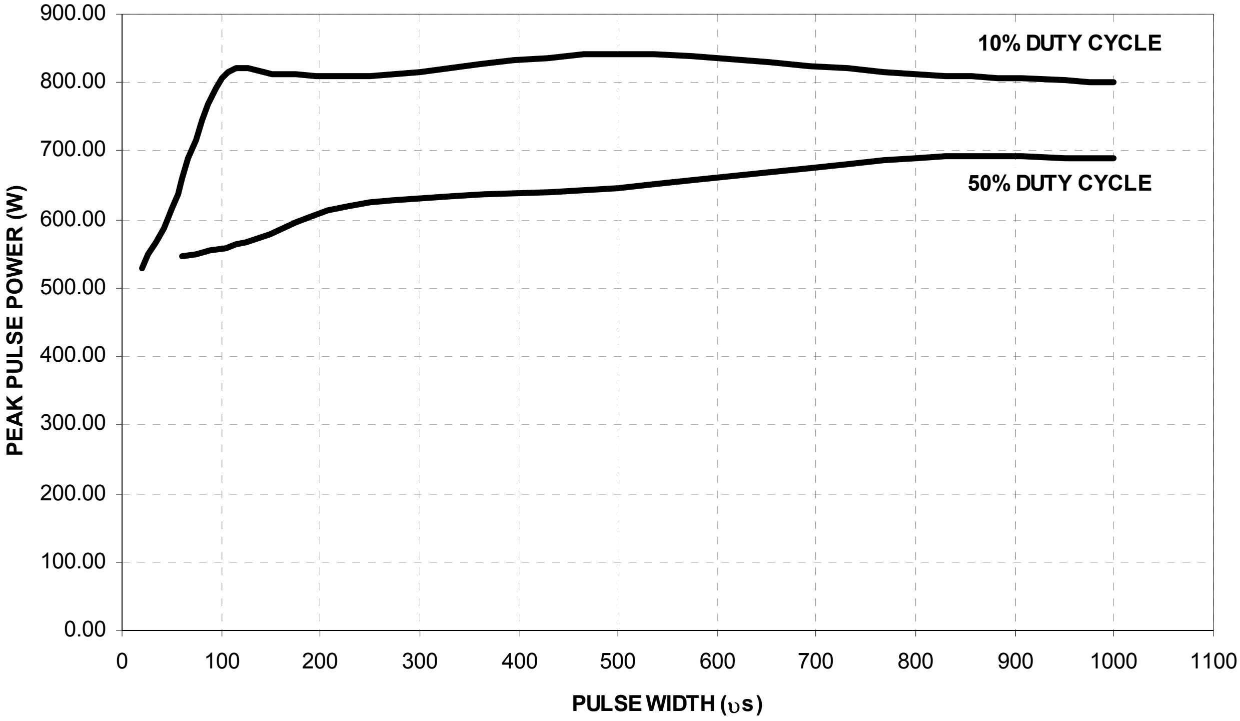
Figure 4-5. Instantaneous Laser Output Power Showing Rise and Fall Times

The form of the instantaneous output power is shown on Figure 4-5a. Each laser pulse has a 40 µs rise time to full power and on the trailing edge a similar 40 µs decay time from full power to no laser output. For laser pulses of several hundred microseconds duration, there is little impact on the laser performance due to this rise and fall time. But for pulses of about 40 µs, the actual laser output is more triangular in shape than square in shape as shown on Figure 4-5b. The advantage of this characteristic is at the short pulse periods, the peak processing power decreases due the rise and fall time. This leads to more process control for many applications. As the pulse period is reduced for these triangular shaped peaks, the bases of the triangles merge into each other. This has the effect of being a quasi CW performance for these short pulse widths. This effect has been observed for pulse period of 100 µs and a pulse width of about 60 µs.

There can be some operating frequencies which cannot produce the minimum output power of 20 W and still have a pulse width in the range noted above. For example, when operating the laser at 50 kHz at the minimum pulse width will produce about 80 W. It is possible to select a combination of pulse width and pulse period that will produce less than 20 W of output power from the Diamond laser. Under these conditions, the power stability generally will exceed the specified value. Performance including such parameters as power stability is guaranteed when the laser is operated over the power range noted in the specifications and for pulse width between 4 µs and 1000 µs.

The high effective processing power of the Diamond laser results from its square-wave pulse performance. The primary variables of the effective processing power are the pulse width and the duty cycle. Figure 4-6 shows the range of the peak power during a pulse for various pulse widths. The pulse power is the average power during a single pulse. Increasing the duty cycle has the effect of moving vertically down on this graph.

For some material processing applications, pulse shaping can be achieved significant improvement in the results. Pulse shaping can be achieved through a burst or group of pulses that might decrease the peak power on the surface. An example is shown in Figure 4-7 where four pulses with a pulse width of 40 µs and a pulse period of 125 µs are being burst at 500 Hz. Other waveforms are possible including ramp ups and down in the optical power. Other useful pulse shapes include a high intensity leading pulse followed by a lower power trailing edge.



Values shown are typical values obtained from a typical Diamond laser with less than 500 hours of operation. They are not intended to reflect performance for each individual laser.

Figure 4-6. Effective Processing Power vs. Pulse Width

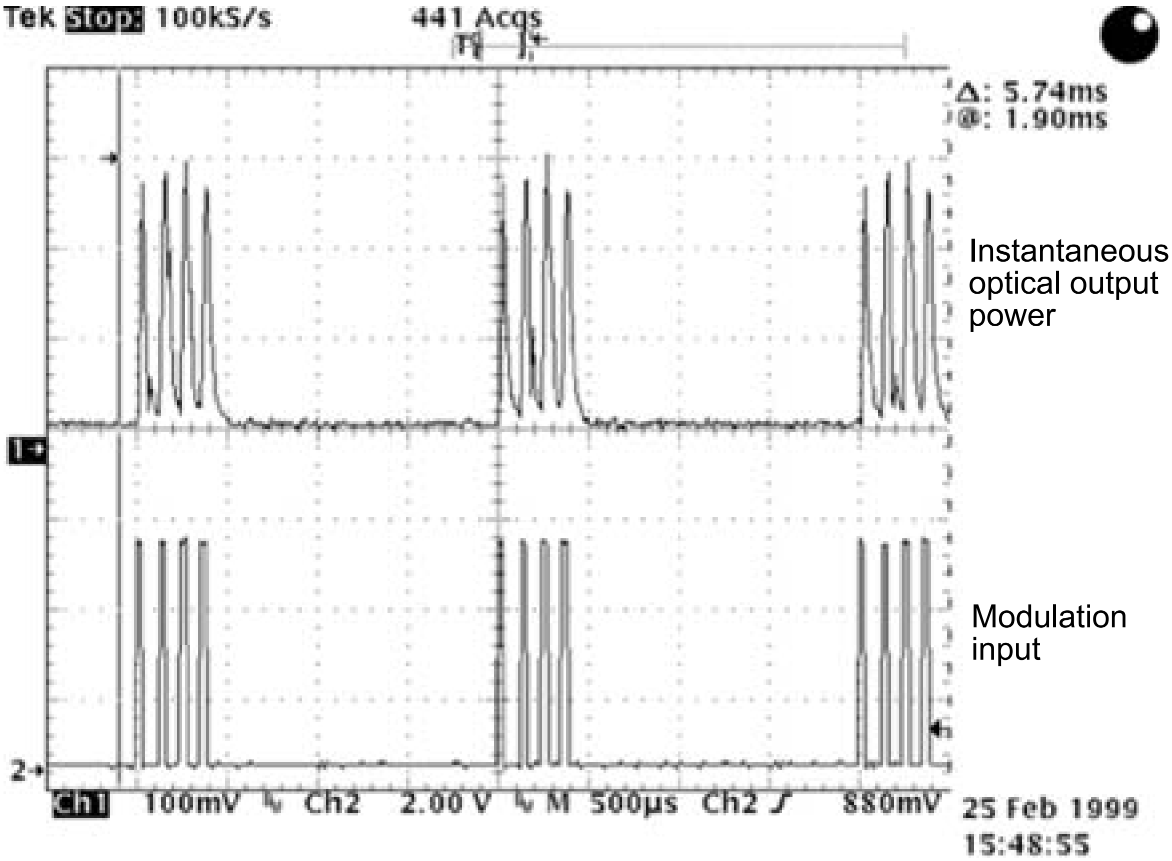


Figure 4-7. Example of Pulse Shaping of the Diamond Output

Shutdown Procedure

The EMERGENCY STOP switch is for emergency use only. Do not use this switch to shut down the laser under normal conditions.

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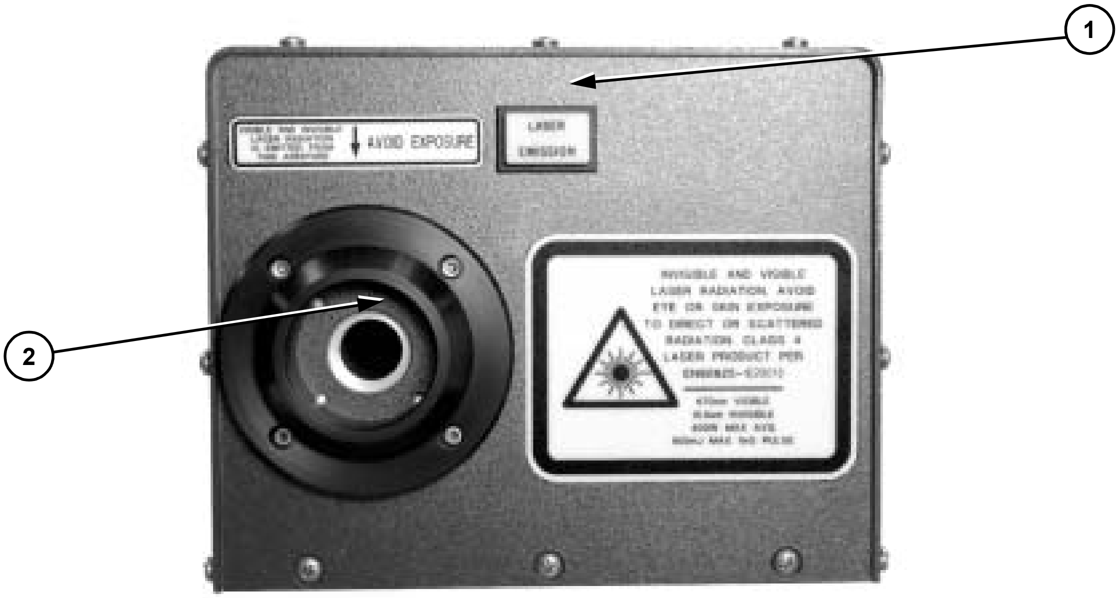
1. Set the remote control unit switches to the positions indicated in Table 4-4.
2. Turn off the facility circuit breaker and facility on/off switch if installed.
3. Turn off the cooling water to the laser. If shut-off valves are available on the source and drain, then turn off the source valve followed by the drain valve.

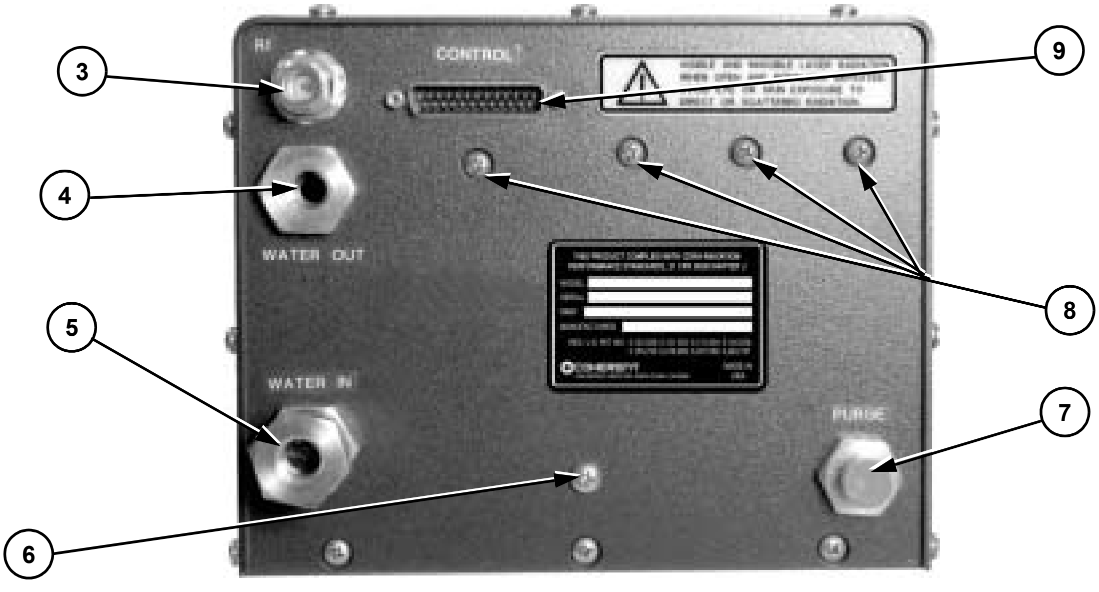
Table 4-4. Remote Control Unit Settings for Laser Shutdown

ACTION	REMOTE CONTROL UNIT SWITCH	INDICATION
Turn off modulation	Set the MODULATION CONTINUOUS/OFF/ MOMENTARY switch to OFF or; Turn off modulation using the external device connected to the REMOTE MODULATION SWITCH connector or; Turn off modulation using the external device connected to the MODULATION GATE connector and set the MODULATION CONTINUOUS/OFF/ MOMENTARY switch to OFF.	MODULATION ON indicator turns off.
Close the shutter	Set the SHUTTER OPEN/CLOSE to CLOSE or; Close the shutter using the external device connected to the REMOTE SHUTTER SWITCH connector.	SHUTTER OPEN indicator turns off.
Turn off aiming beam	Set the AIMING BEAM switch to OFF.	Aiming beam is no longer visible.
Turn off laser power	Set the ON/OFF keyswitches on the remote control unit and power module to OFF.	All indicators turn off.

Controls and Indicators


1
2
AVOID EXPOSURE
LASER EMISSION
INVISIBLE AND VISIBLE LASER RADIATION. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. CLASS 4 LASER PRODUCT PER

FRONT VIEW



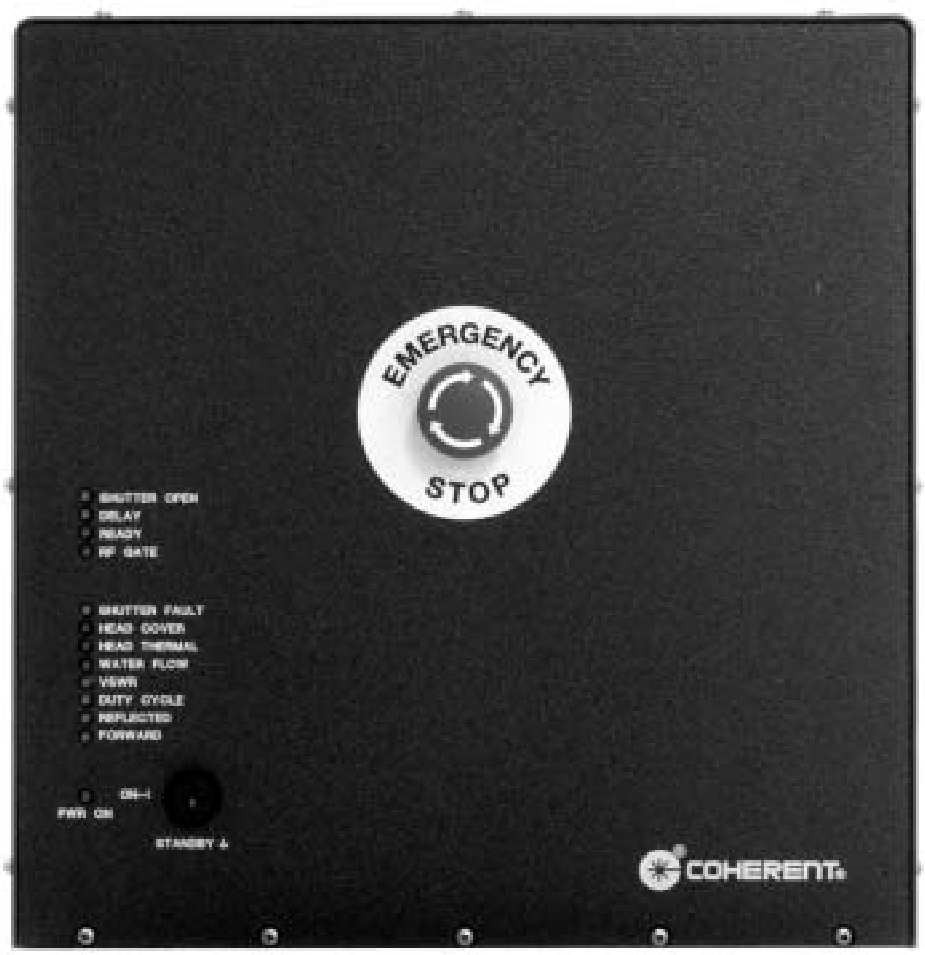
REAR VIEW

1. Emission indicator	6. Ground stud
2. Beam exit aperture	7. Nitrogen purge fitting
3. RF cable connector	8. Head board mounting screws
4. WATER OUT hose connector	9. CONTROL cable connector
5. WATER IN hose connector	

Figure 4-8. Laser Head Indicators and Connectors

Table 4-5. Laser Head Indicators and Connectors

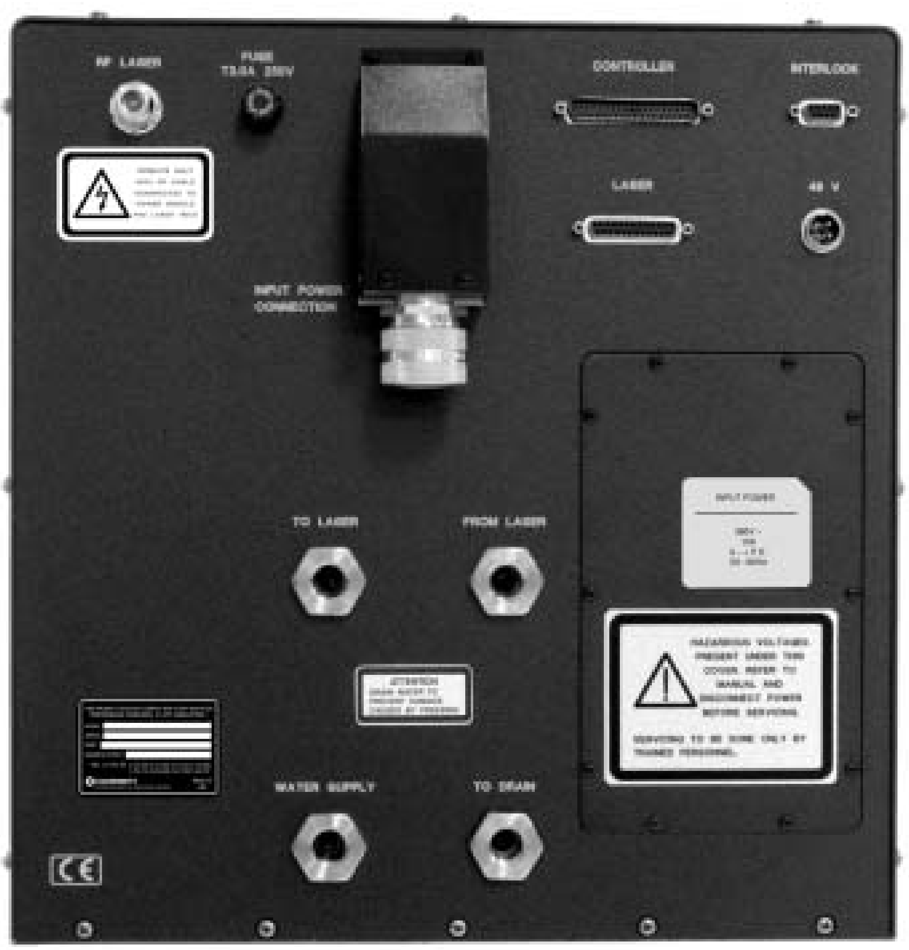
INDEX	CONTROL	FUNCTION
1.	Emission indicator	On whenever the laser is capable of emitting radiation.
2.	Beam exit aperture	Either the main output beam or the aiming beam exits the laser head from this aperture. When the main beam exits the aperture (shutter open), the aiming beam cannot exit. When the aiming beam exits the aperture (shutter closed), the main beam cannot exit. Note that the aiming beam can be turned off (AIMING BEAM switch) and the main beam can be turned off (MODULATION switch) from the remote control unit.
3.	RF cable connector	Connector for RF cable that supplies RF from the power module to the tube through the supplied RF interconnection cable. Refer to Figure 3-8 for the laser system interconnection diagram.
4.	WATER OUT water hose connector	Connection for the 3/8" I.D. nylon reinforced PVC cooling water hose between the laser head and the power module. Refer to Figure 3-8 for the laser system interconnection diagram. Refer to Chapter Three, Utility Requirements and System Installation, for additional information on cooling water and closed loop cooling systems.
5.	WATER IN water hose connector	Connection for the 3/8" I.D. nylon reinforced PVC cooling water hose that supplies water to the laser head from the power module. Refer to Figure 3-8 for the laser system interconnection diagram. Refer to Chapter Three, Utility Requirements and System Installation, for additional information on cooling water and closed loop cooling systems.
6.	Ground stud	This is provided for electrical grounding to the laser head. Connect to the facility ground using 12 AWG wire size (minimum) maximum length 60 inches (1.5 meters).
7.	PURGE connector	Standard gas fitting for purging the optics in the laser head. The purging nitrogen gas exits through the beam exit aperture. Nitrogen is not required for tube operation. Refer to Chapter One, Description and Specifications, for additional information on purging the laser head.
8.	Mounting screws	Secures the laser head board located inside the laser head.
9.	CONTROL cable connector	Connector for DB25 interconnection cable between the laser head and the power module. This cable supplies control signals to the laser head and supplies status information from the head. Refer to Table 4-10 for a list of signals that travel through this cable. Refer to Figure 3-8 for the laser system interconnection diagram.



FRONT VIEW

1. EMERGENCY STOP switch (twist to turn on)
2. SHUTTER OPEN indicator
3. DELAY indicator
4. READY indicator
5. RF GATE indicator
6. SHUTTER FAULT indicator
7. HEAD COVER indicator
8. HEAD THERMAL indicator
9. WATER FLOW indicator
10. VSWR indicator
11. DUTY CYCLE indicator
12. REFLECTED indicator
13. FORWARD indicator
14. LASER EMISSION indicator
15. Keyswitch

Figure 4-9. Power Module Controls, Indicators, and Connectors



REAR VIEW

16. RF LASER connector
17. FUSE T 3.0A 250V
18. LASER control cable connector
19. CONTROLLER connector
20. INTERLOCK connector
21. 48V connector
22. Input power field service box
23. WATER SUPPLY water hose connector
24. TO DRAIN water hose connector
25. FROM LASER water hose connector
26. TO LASER water hose connector
27. Input line voltage selector

Figure 4-9. Power Module Controls, Indicators, and Connectors (Continued)

Table 4-6. Power Module Controls, Indicators, and Connectors

INDEX	CONTROL	FUNCTION
1.	EMERGENCY STOP switch	Pressing this red switch turns off the Diamond laser. This switch is for use in emergency situations only and must not be used as a substitute for system shutdown. The switch must be turned clockwise before the laser can be restarted using the normal startup procedure.
2.	SHUTTER OPEN indicator	Amber indicator turns on when the shutter is open. Active in both SHUTTER REMOTE/LOCAL switch positions. Flashes when there is a shutter fault.
3.	DELAY indicator	Amber indicator flashes on and off when the system delay of approximately 10 seconds is in process. The delay occurs at system startup from a cold start and after clearing a fault. This indicator turns off when the delay is complete.
4.	READY indicator	Green indicator turns on when the system is ready for operation and there are no faults.
5.	RF GATE indicator	Green indicator turns on when there are no interlock or fault problems.
6.	SHUTTER FAULT indicator	Red indicator turns on indicating the shutter is not in the commanded position. When shutter fault active laser operation is not possible.
7.	HEAD COVER indicator	Red indicator turns on typically indicating that the head cover is not securely attached. If the laser head cover has been removed for maintenance, an interlock defeat must be installed. The system will be held in an off condition, not start, or restart when this indicator is on. Refer to the Table 5-1 for information on troubleshooting and clearing this condition.
8.	HEAD THERMAL indicator	Red indicator turns on indicating excessive heat buildup on the shutter assembly beam dump which dissipates heat when the shutter is closed since the Diamond may continue to lase when the shutter is closed. This is usually caused by insufficient water flow to the shutter. The system will be held in an off condition, not start, or restart when this indicator is on. Refer to the Table 5-1 for information on troubleshooting and clearing this condition.
9.	WATER FLOW indicator	Red indicator turns on indicating that the water flow is too low or is flowing in the wrong direction. The system will be held in an off condition, not start, or restart when this indicator is on. Refer to the Table 5-1 for information on troubleshooting and clearing this condition.
10.	VSWR indicator	Amber indicator turns on indicating that the ratio of the RF reflected voltage to the RF forward voltage exceeds the factory set indicator is limit. Indicator will be illuminated only when such a fault occurs. The indicator can be reset by toggling the RESET switch. The indicator on continuously indicates a problem with the laser tube or the RF cable. Refer to the Table 5-1.

Table 4-6. Power Module Controls, Indicators, and Connectors (Continued)

INDEX	CONTROL	FUNCTION
11.	DUTY CYCLE indicator	Amber indicator turns on indicating that the duty cycle of the pulse exceeds 60% or a pulse width exceeds 1000 µs. Duty cycle is the ratio of the pulse width to the pulse period multiplied by 100%. Indicator is illuminated only when fault occurs. Refer to Figure 4-4 for operating parameters limits. The indicator can be reset by toggling the RESET switch.
12.	REFLECTED indicator	Amber indicator turns on indicating that the reflected RF power from the laser tube (monitored by the RF amplifier located in the power module) is greater than a factory set level. Indicator is illuminated only when fault exists. The indicator on continuously indicates a potential problem with the tube. The indicator can be reset by toggling the RESET switch. Refer to the Table 5-1.
13.	FORWARD indicator	Amber indicator turns on indicating that the forward RF power from the RF amplifier to the laser head is lower than a factory set level indicator is illuminated only when fault exists. If indicator is on continuously, this could indicate a problem with the RF power supply. The indicator can be reset by toggling the RESET switch. Refer to the Table 5-1.
14.	PWR ON indicator	Green indicator turns on indicating that +48 V power is applied in the power module. The keyswitch on both the remote control unit and on the power module must be turned on before this indicator will light.
15.	Keyswitch	Turns on the DC power supply once a second keyswitch on the remote control unit is turned on.
16.	RF LASER connector	Connector for RF cable that supplies RF from the RF amplifier (located in the power module) to the tube through the supplied RF interconnection cable. Refer to Figure 3-8 for the laser system interconnection diagram.
17.	FUSE T 3.0 A 250V	3 Amp slo blo fuse for accessory items powered by 48 V. (This does not include the RF Amplifier)
18.	LASER control cable connector	Connector for DB25 interconnection cable between the laser head and the power module. This cable supplies control signals to the laser head and supplies status information from the head. Refer to Appendix A for a list of signals that travel through this cable. Refer to Figure 3-8 for the laser system interconnection diagram.
19.	CONTROLLER connector	Connector for the 37 pin interconnection cable between the remote control unit and the power module. This cable supplies control signals from the remote control unit and supplies status information from the power module. Refer to Appendix A for a list of signals that travel through this cable. Refer to Figure 3-8 for the laser system interconnection diagram.

Table 4-6. Power Module Controls, Indicators, and Connectors (Continued)

INDEX	CONTROL	FUNCTION
20.	INTERLOCK connector	Allows connection of a customer furnished external safety interlock that will automatically shut down the laser when opened and allow laser operation when closed. The system is shipped with a plug which must be installed for the system to be turned on. If the plug is removed, the system will not operate. Pins 3 to 6, 4 to 8, and 5 to 9 must be shorted either by the plug or by a user furnished safety interlock.
21.	48V connector	Supplies +48 VDC to the remote control unit. Protected by fuse on the rear panel. See Table 4-11 for pin outs.
22.	Input power	Field terminal box cover input power terminals. A four wire connector that connects to a facility power outlet. The Diamond can operate from either 208 VAC or 380 VAC, 3Ø power. Refer to Chapter Three, Utility Requirements and System Installation for additional information on connecting the power module to facility power.
23.	WATER SUPPLY water hose connector	Connection for the 3/8" (9.5 mm) I.D. nylon reinforced PVC cooling water hose that supplies cooling water to the power module. Use the appropriate fittings supplied with the laser. Refer to Figure 1-5 for a cooling system diagram. Refer to Chapter Three, Utility Requirements and System Installation, for additional information on cooling water and closed loop cooling systems.
24.	TO DRAIN water hose connector	Connection for the 3/8" I.D. nylon reinforced PVC cooling water hose between the facility water drain and the power module. Use the appropriate fittings supplied with the laser. Refer to Figure 1-5 for a cooling system diagram. Refer to Chapter Three, Utility Requirements and System Installation, for additional information on cooling water and closed loop cooling systems.
25.	FROM LASER water hose connector	Connection for the 3/8" I.D. nylon reinforced PVC cooling water hose that returns cooling water from the laser head to the power module. Refer to Figure 1-5 for a cooling system diagram. Refer to Chapter Three, Utility Requirements and System Installation, for additional information on cooling water and closed loop cooling systems.
26.	TO LASER water hose connector	Connection for the 3/8" I.D. nylon reinforced PVC cooling water hose that supplies cooling water to the laser head. Refer to Figure 1-5 for a cooling system diagram. Refer to Chapter Three, Utility Requirements and System Installation, for additional information on cooling water and closed loop cooling systems.
27.	Input line voltage selector	Allows operation from a 208 VAC or a 380 VAC, 50 to 60 Hz, 3 Ø line voltage with ground. Refer to Chapter Three, Utility Requirements and Installation, for instructions on the use of this selector. The laser must be turned off and the power cord must be removed from facility power prior to removing the line selector.

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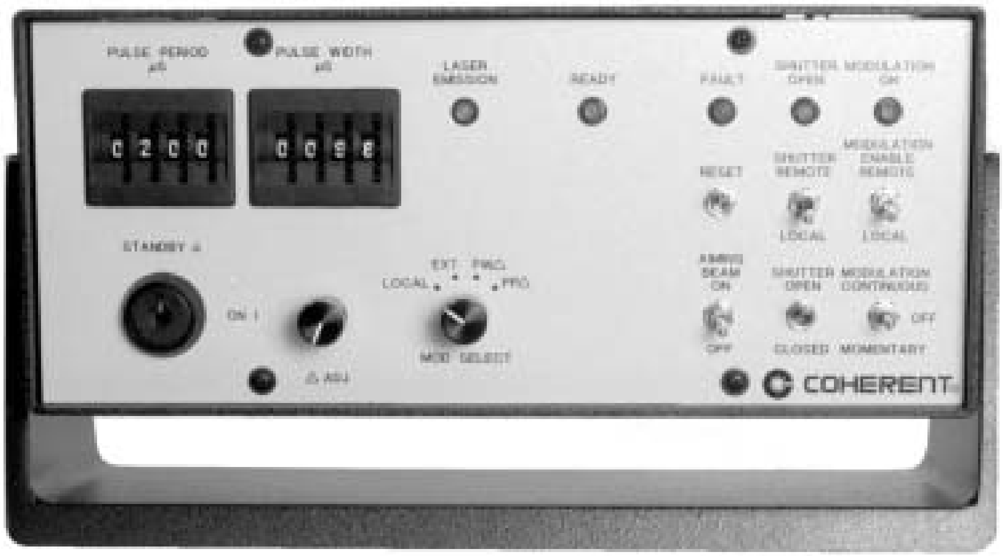


1. PULSE PERIOD µs thumbwheel switch and numeric readout
2. PULSE WIDTH µs thumbwheel switch and numeric readout
3. LASER EMISSION indicator
4. READY indicator
5. FAULT indicator
6. SHUTTER OPEN indicator
7. MODULATION ON indicator
8. RESET switch
9. SHUTTER REMOTE/LOCAL switch
10. MODULATION ENABLE switch
11. ON/OFF keyswitch
12. Δ ADJ control knob
13. MOD SELECT switch
14. AIMING BEAM switch
15. SHUTTER OPEN/CLOSED switch
16. MODULATION CONTINUOUS/OFF/MOMENTARY switch

Figure 4-10. Remote Control Unit Controls and Indicators – Front Panel

Table 4-7. Remote Control Unit Controls and Indicators – Front Panel

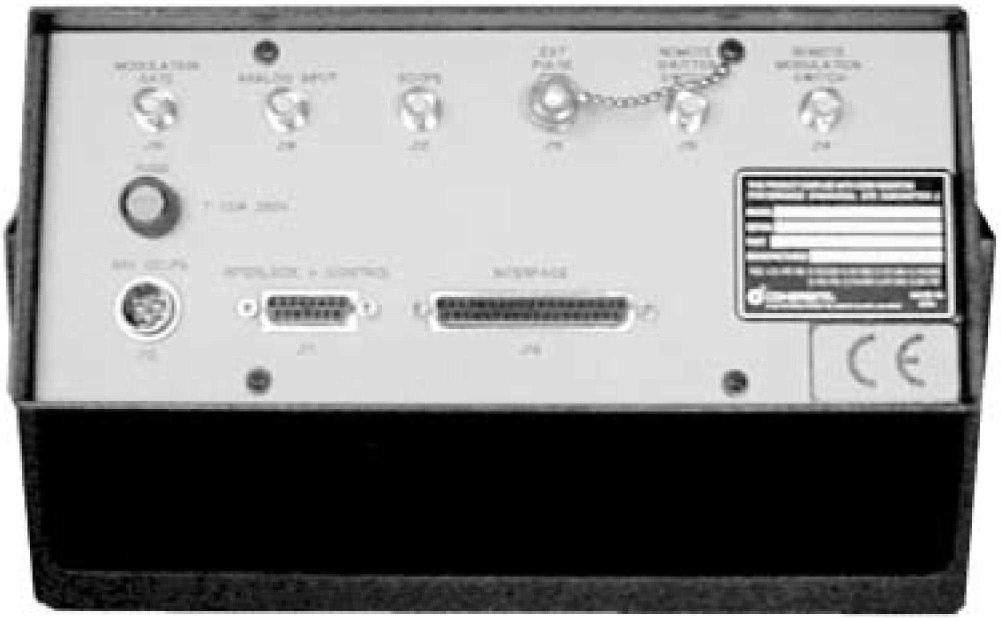
INDEX	CONTROL	FUNCTION
1.	PULSE PERIOD μs thumbwheel switch and numeric readout	Allows selection of the RF pulse period when the remote control unit is used to control the modulation input to the RF amplifier (MODULATION ENABLE switch set to LOCAL). The readout is in microseconds in whole numbers (no decimals). The value selected should be 1.67 times the pulse width or greater. The switches are inactive when an external source is used (MOD SELECT switch set to EXT or PPΔ mode). A typical pulse period is shown on Figure 4-1. Refer to Figure 4-6 for operating ranges.
2.	PULSE WIDTH μs thumbwheel switch and numeric readout	Allows selection of the RF pulse width when the remote control unit is used to control the modulation input to the RF amplifier (MODULATION ENABLE switch set to LOCAL). The readout is in microseconds in whole numbers (no decimals). The left thumbwheel switch is locked in the 0 position since the maximum pulse width is 999 μs. The switches are inactive when an external source is used (MOD SELECT switch set to EXT or PWΔ mode). A typical pulse period is shown on Figure 4-1. Refer to Figure 4-6 for operating ranges.
3.	LASER EMISSION indicator (green)	On whenever the laser is capable of emitting radiation.
4.	READY indicator (green)	Turns on when the system is ready for operation and no faults are present.
5.	FAULT indicator (red)	Flashes when a system fault condition has occurred. Refer to the red indicator lights on the front panel of the power module for the source of the fault.
6.	SHUTTER OPEN indicator (amber)	Lights when the shutter is open. Flashes when there is a shutter fault and the shutter is not in the selected position. Active in both the SHUTTER REMOTE/LOCAL switch positions.
7.	MODULATION ON indicator (amber)	Lights when a modulation signal is being applied to the RF amplifier. This indicator functions in both positions of the MODULATION ENABLE switch.
8.	RESET switch	A momentary switch that will reset fault (red) or warnings (amber) conditions by toggling the switch. Fault conditions are registered by a flashing FAULT indicator and alerts are registered by the amber indicators (FORWARD, REFLECTED, DUTY CYCLE, and VSWR) on the power module. This switch also resets the fault and warning indicators on the power module front panel.

Table 4-7. Remote Control Unit Controls and Indicators – Front Panel (Continued)

INDEX	CONTROL	FUNCTION
9.	SHUTTER REMOTE/ LOCAL switch	When set to LOCAL, the shutter position is controlled by the SHUTTER OPEN/CLOSED switch on the remote control unit front panel. When set to REMOTE, the shutter position is controlled by an external device connected to the REMOTE SHUTTER SWITCH J15 located on the remote control unit rear panel. A contact closure (connection to return) is required from an external source to operate the shutter. Alternately, the shutter will close with TTL high and open when TTL low is applied to the REMOTE SHUTTER SWITCH J15.
10.	MODULATION ENABLE switch	When set to LOCAL, the laser on and off condition is controlled by the MODULATION CONTINUOUS/OFF/MOMENTARY switch. When set to REMOTE, the laser on and off condition is controlled by a relay closure connected to the BNC connector labelled REMOTE MODULATION SWITCH J14 on the remote control unit rear panel. Alternately, modulation can be turned on by TTL low at the REMOTE MODULATION SWITCH input and turned off with TTL high.
11.	ON/OFF keyswitch	Turns on the DC power supply once a second key switch on the power module is also turned on.
12.	Δ ADJ control knob	This knob provides continuously adjustable laser power when the MOD SELECT switch is set to the PWΔ or PPΔ position. Turn the knob approximately 1/4 turn from the fully CCW position before the MODULATION CONTINUOUS/OFF/MOMENTARY switch is set to either of the ON positions. When the knob fully CCW, laser power can be adjusted by varying the voltage applied to the BNC connector labelled ANALOG INPUT J18 on the remote control unit rear panel.
13.	MOD SELECT switch	The LOCAL position allows controlling laser power using the PULSE WIDTH µs and PULSE PERIOD µs switches on the remote control unit front panel. The EXT position allows controlling laser power using an external signal generator connected to EXT PULSE GEN J16 connector on the remote control unit rear panel. The PWΔ position allows controlling laser power by varying the pulse width (ΔADJ control knob) at a constant pulse period. The PP Δ position allows controlling laser power by varying the pulse period (ΔADJ control knob) at constant pulse width.
14.	AIMING BEAM ON/OFF switch	Turns the aiming beam on and off. The aiming beam is visible only when the shutter is closed.

Table 4-7. Remote Control Unit Controls and Indicators – Front Panel (Continued)

INDEX	CONTROL	FUNCTION
15.	SHUTTER OPEN/CLOSED switch	Allows operation of the shutter from the remote control unit. The status of the shutter is indicated by the SHUTTER OPEN indicator on the remote control unit front panel. This switch is disabled when the SHUTTER REMOTE/LOCAL switch is set to REMOTE. When the shutter is open, only the main beam can exit the laser. When closed, the aiming beam can exit the laser. The aiming beam can be turned on and off using the AIMING BEAM switch.
16.	MODULATION CONTIN-UOUS/OFF/ MOMENTARY switch	Selects continuous, momentary, or no modulation for either an external source or the internal modulation source. This switch is functional only when the MOD ENABLE switch is in the LOCAL position. If the MODULATION GATE J19 function on the rear panel is being used, laser operation is achieved by applying a signal of 0VDC along with activating the modulation switch as described below. When the MOD ENABLE switch is in the REMOTE position, modulation to the laser is determined by the signal applied to at the REMOTE MODULATION SWITCH J14 connector on the remote control unit rear panel.
	CONTINUOUS:	The laser is turned on and operates at the specific pulse width and pulse period selected by the modulation source. The modulation source is determined by the position of the MOD SELECT switch. The switch will remain in the CONTINUOUS position until moved to another position.
	MOMENTARY:	Identical function to the CONTINUOUS position except that the laser will go off as soon as the switch is released.
	OFF:	The laser is turned off when in this position and no output beam will be emitted from the laser.



1. MODULATION GATE J19 connector
2. ANALOG INPUT J18 connector
3. SCOPE J17 connector
4. EXT PULSE GEN J16 connector with shorting cap installed
5. REMOTE SHUTTER SWITCH J15 connector
6. REMOTE MODULATION SWITCH J14 connector
7. Fuse T 1.0A 250V
8. 48 VDC P/S J12 connector
9. INTERLOCK + CONTROL J11 connector
10. INTERFACE J13 connector

Figure 4-11. Remote Control Unit Controls and Indicators – Rear Panel

Table 4-8. Remote Control Unit Controls and Indicators – Rear Panel

INDEX	CONTROL	FUNCTION
1.	MODULATION GATE J19 connector	Input to this connector allows for independent control of the modulation output from the control unit. Modulation is allowed with a TTL low at this pin and not allowed with a TTL high at 20 mA. In order for the laser to operate, use the MODULATION CONTINUOUS/OFF/ MOMENTARY switch or provide an input at the REMOTE MODULATION SWITCH.
2.	ANALOG INPUT J18 connector	Allows for continuously variable power when the MOD SELECT switch on the front panel is in the PWΔ or PPΔ position and the ΔADJ rotatory switch is full CCW and clicked into the off position. The input voltage can be varied between 0 and +10 V with up to 0.5 mA with the power increasing with an increase in the voltage.
3.	SCOPE J17 connector	Allows monitoring the output pulse width and pulse period signal that is provided to the RF amplifier located in the power module. This is a TTL compatible signal with the duration at a TTL high equal to the pulse width.
4.	EXT PULSE GEN J16 connector	Allows connection to an external pulse generator. Complex pulse formats are available when using this connection. The input level at this connector must be a TTL high to turn the laser on and a TTL low for the laser to be off. Leave the signal generator on when using this input. Switch the laser on and off using the MODULATION switch or REMOTE MODULATION SWITCH or THE MODULATION GATE. Select this input by setting the MOD SELECT switch to EXT. If an input is not connected to this input ensure that the shorting BNC cap is installed.
5.	REMOTE SHUTTER SWITCH J15 connector	Connects to the laser head shutter to allow remote control of the shutter. Applying a contact closure will close the shutter when the SHUTTER REMOTE/LOCAL switch on the front panel is in the REMOTE position. Alternately, an input of a TTL low will open the shutter and a TTL high will close the shutter.
6.	REMOTE MODULATION SWITCH J14 connector	Allows remote control of the modulation output from the remote control unit. This input is active when the MODULATION ENABLE switch is in the REMOTE position. A TTL low or contact closure will turn the laser modulation on and a TTL high or open contact will turn it off. There can be a delay of 3 ms between turning the system on at this point and applying the modulation signal to the laser.
7.	FUSE T 1.0A 250V	Protects remote control unit on the +48 VDC input line from the power module (1.0 Amp slow blow).
8.	48V DC P/S J12 4 pin connector	Connects the remote control unit to the DC power supply located in the power module. Power is supplied to this unit through this connector. Refer to Table 4-11 for pinouts.
9.	INTERLOCK + CONTROL J11 connector	This is a 15 pin connector that allows alternate inputs/outputs for the functions described in index numbers 1 through 6 in this table. Refer to Table 4-9 for a list of signals associated with this connector. Pins 14 and 15 must be connected for the laser to turn on. Use the plug provided to provide this function.
10.	INTERFACE J13 connector	37 pin connector that interfaces the remote control unit to the DDI board located in the power module.

Table 4-9. Remote Control Unit Controls and Indicators INTERLOCK + CONTROL Connector Pin Out

PIN NUMBER	**DESCRIPTION**
1.	Alternate input for MODULATING GATE. Refer to Table 4-8 for description of operation with this input signal.
2.	Alternate input for EXT PULSE GEN. Refer to Table 4-8 for description of operation with this input signal.
3.	Alternate output for SCOPE. Refer to Table 4-8 for description of this output signal.
4.	Alternate input for REMOTE MOD SWITCH. Refer to Table 4-8 for description of operation with this input signal.
5.	Alternate input for REMOTE SHUTTER SWITCH. Refer to Table 4-8 for description of operation with this input signal.
6.	Alternate input for ANALOG INPUT. Refer to Table 4-8 for description of operation with this input signal.
7.	Performs the same function as LASER EMISSION indicator on the front panel. This output will be at a TTL high when the LASER EMISSION indicator is illuminated.
8.	Performs the same function as the READY indicator on the front panel. This output will be at a TTL high when the READY indicator is illuminated.
9 and 10.	Signal ground for pins 1 to 8 and 11 to 13.
11.	Performs the same function as the FAULT indicator on the front panel. When a fault is present this signal will alternate between a TTL high and a TTL low with a period of about 1 second.
12.	Performs the same function as the MODULATION ON indicator. When the modulation is turned on, the output will be at a TTL high.
13.	Performs the same function at the SHUTTER OPEN indicator. This output will be at a TTL high when the shutter is open
14.	Allows connection of a customer furnished external safety interlock that will automatically shut down the laser when open and allow operation when closed. In the plug provided with the system it is connected to pin 15.
15.	Return for the interlock as described for pin 14. Connected to pin 14 in the plug provided with the system.

Table 4-10. Laser Head DB25 Connector Pinouts

PIN NUMBER	FUNCTION	DESCRIPTION
1 through 5	+48 V	+48 V power from the DC power supply located in the power module unit. The 48 V provides power for the laser head board and the shutter assembly.
6 through 10	+48 V return	Return for pins 1 through 5. Tied to 48 V return (DC power supply negative buss bar). Also returns for pin 14 and 25.
11 and 12	Water flow interlock (+/–)	Differential signal indicating the water flow is at or above the required flow rate and is flowing in the proper direction. With the correct water flow, pin 11 will be >3 V and pin 12 will be <1 V. These states will reverse when the water flow is in a fault condition and light the interlock indicator on the remote control unit.
13 and 15	Shutter thermal sensor interlock (+/–)	Differential signal indicating the water cooled shutter is in the proper temperature range. In this correct temperature range, pin 13 will be >3 V and pin 15 will be <1 V. In the fault or over temperature condition, these states will reverse and light the interlock indicator on the remote control unit.
14	Aiming beam	Contact open turns on the aiming beam.
16 and 17	Shutter status indicator (+/–)	Differential signal indicating the shutter position. With the shutter open, pin 16 will be >3 V and pin 17 will be <1 V. When the shutter is closed, the state of these pins will reverse. When the status alternates at several Hz, the shutter is in between these two states and indicates a fault condition. The shutter status is displayed on the remote control unit. A fault condition causes the SHUTTER OPEN indicator to flash on and off.
18	Power monitor	Future option
19	Power monitor	Future option
20 and 21	Cover interlock (+/–)	Differential signal indicating the head cover is properly positioned and secured. In this condition, pin 20 will be >3 V and pin 21 <1 V. The states will reverse when the head cover is removed and light the interlock indicator on the remote control unit.
22 and 23	Cable interlock	Connected to switch of remote control unit. Will allow 48 VDC supply to be turned on only if this 25 pin connector is connected to laser head.
24	Not used	
25	Shutter drive	Contact closure causes shutter to open.
Note: For differential signals the first pin number indicated is positive (+) and the second pin number will be the negative (–).		

Table 4-11. Pinouts for +48V Connector (Rear Panel of Power Module)

PIN NUMBER	DESCRIPTION
1	+48 V
2	Internal interlock (+5 VDC)
3	Internal interlock (+5 VDC)
4	+48 Return

OPERATOR'S MANUAL

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CHAPTER FIVE
MAINTENANCE AND TROUBLESHOOTING

COHERENT

Introduction

This chapter contains preventive maintenance procedures, troubleshooting, and corrective actions.

The laser is intended for operation with all covers in place. Procedures that require removing a cover should be performed by qualified trained personnel. The shutdown procedures must be performed prior to cover removal.

Preventive Maintenance

Monthly inspection of water and electrical connections will assist in keeping the laser system in good operating condition.

Water System Inspection

Inspect water hoses, fittings, and connections for signs of wear, cuts, nicks, corrosion, or leaks. Water connections are located on the power module, on the laser head rear end plate, and inside the laser head. In addition, inspect laser system connections to facility water supply and drain lines. Repair water leaks and replace worn hoses immediately.

Do not remove the power module cover at any time. This unit contains no user serviceable components. Do not remove the laser head cover unless specifically instructed in this manual. The laser is intended for operation with the cover in place. Procedures that require removing the cover should be performed by qualified trained personnel. The shutdown procedures must be performed prior to cover removal.

Electrical Inspection

Do not remove the power module cover. Do not remove the laser head cover unless specifically instructed in this manual. The laser is intended for operation with the cover in place. Procedures that require removing the cover should be performed by qualified trained personnel. The shutdown procedures must be performed prior to cover removal.

Perform the shutdown procedures prior to performing the electrical inspection. Disconnect the power module line cord from facility power.

- Inspect electrical connections to ensure good contact.
- Also check that wiring and insulation are in good condition, free of cuts, nicks, and excessive wear. Look for discoloration on the wire insulation, a sign that excessive heat is building up in the wire. In addition, inspect the wiring to your connector and the facility AC hook-up for signs of overheating.
- Inspect electrical connections inside the laser head.
- Ensure the connectors on the remote control unit, power module, and laser head are securely connected.
- Ensure the RF cable between the power module and laser head is securely connected (no tools are required—finger tight is sufficient).

Purge Gas Filter Kit (option)

Regular maintenance of the purge gas filter kit is required to ensure maintaining the required quality of the purge gas entering both the laser head and the beam delivery optics.

On a weekly basis:

- Inspect filters and gas lines for any sign of leaks or damaged purge tubing. Repair leaks and replace any damaged purge tubing.
- The coalescing filters will collect both liquid oil and water and will automatically discharge this liquid when it reaches a specific level. Push the float at the bottom of the filter bowl to make sure that it moves freely.

Every six months:

- Replace filter cartridges in side filter assemblies. Replace more frequently if required. Remember the DX filter is first and the BX is the second filter as shown in Figure 3-1. To change the filter, first turn off the laser and turn off the purge gas. Remove the bowl of the DX filter and clean out bowl. Replace the DX filter and replace the bowl. Perform the same steps now for the BX filter.

Cleaning

The remote control, laser head, and power module should be cleaned periodically. The interval of cleaning depends on the environmental conditions. Turn off the laser according to the procedure in Chapter Four, Daily Operation. Typically, using a dry clean cloth is sufficient to remove dust and dirt that build up on the unit. Wipe all surfaces with the cloth. If the unit is not sufficiently cleaned by this method then use a cloth dampened with a mild detergent dissolved in water. Take care when cleaning the surfaces not to get moisture into switches, connectors, or the laser aperture.

Troubleshooting

Charts 1 through 7 provide troubleshooting flow charts. The numbered paragraphs that are part of the chart contain supplemental information. The numbered paragraphs are cross referenced to the boxes in the flow charts.

The charts and symptoms are summarized in Table 5-1 which also contains explanations of the LEDs on the remote control unit.

When troubleshooting the Diamond laser system, ensure that the laser output beam will be safely contained. One practical method is to direct the output power into a laser power meter such as a Coherent FieldMaster with a 200 Watt detector head. A 200 µsec pulse width and a 6000 µsec pulse period will produce between 25 and 35 Watts of output power. These settings are recommended for troubleshooting. The troubleshooting flow charts also assume that all external equipment such as pulse generators have been disconnected.

If defective parts are found as a result of troubleshooting, replacement parts should be ordered from Coherent. When ordering replacement parts see Appendix B for appropriate part number. To ensure safe operation of this unit, use only Coherent parts available from Coherent or your Coherent representative.

Faults and Warnings in the Diamond™ K-300 System

This section describes the function of the red fault indicators and the amber warning indicators on the power module and the remote control unit. An active fault in the Diamond system is displayed by an illuminated red indicator on the front panel of the power module. When a fault is active, operation of the laser is prohibited by the Diamond Digital Interface in the power module. Further operation of the laser under a fault condition could damage the laser or is not safe for the operator. The fault conditions are as follows:

WATER FLOW—less than 1.5 gallons per minute through the laser head and power module

HEAD THERMAL—temperature in excess of 60°C on the water cooled shutter

HEAD COVER—the cover to the laser head is not secured

SHUTTER FAULT—shutter is not completely in the selected position

An active amber indicator on the power module indicates a situation to note but will not terminate the operation of the Diamond system. These indicators show two general events:

1. Status of system operation
2. Conditions which could possibly indicate erratic system operation.

There are six amber indicators on the front panel of the power module with the following labeling and description of their function. The conditions described first are active during normal operation of the system.

SHUTTER SENSE—will turn on when the shutter is open and the laser beam can exit the laser head. This indicator will flash if the shutter does not completely open or close. Under these latter conditions the SHUTTER FAULT indicator will also be illuminated.

DELAY—will turn on when the start delay of about 8 seconds is in progress. Laser operation is disabled during this period.

The warning light will be illuminated only when the fault is active. There are transient starting conditions that will occasionally exist and result in this indicator being momentarily illuminated. If the indicator is illuminated continuously, then this indicates a potential problem with the RF cable or the laser tube. The FAULT RESET switch on the front panel of the remote control unit will clear this indicator.

DUTY CYCLE—when illuminated indicates that the pulse width is greater than 1000 µs, or operating at a duty cycle of 60% or greater. Reduce the duty cycle to less than 60% or the pulse width to less than 1000 µs and this light should no longer be illuminated. This warning will be illuminated only when the fault is active.

VSWR—when illuminated indicates that the ratio of the reflected RF voltage to the forward RF voltage has exceeded a preset level. The warning light will be illuminated only when the fault is active. There are transient starting conditions that will occasionally exist and result in this indicator being momentarily illuminated. If the indicator is illuminated continuously, then this indicates a potential problem with the RF cable or the laser tube. the FAULT RESET switch on the front panel of the remote control unit will clear this indicator.

FORWARD—when illuminated indicates that the forward RF voltage to the laser tube has fallen below a preset value. This indicator will be illuminated only when the fault is active there are transient starting conditions that occasionally exist and result in the indicator being momentarily illuminated. If the indicator is being continuously this indicates a potential problem with the RF power supply. The FAULT RESET switch on the remote control unit will clear this indicator.

REFLECTED—when illuminated indicates that the reflected RF voltage from the tube and RF cable exceeds a preset value. This indicator will be illuminated only when the fault is active. There are transient starting conditions that will occasionally exist and result in this indicator being momentarily illuminated. If the indicator is being continuously illuminated then this indicates a potential problem with the RF cable or the laser tube. The FAULT RESET switch on the remote control unit will clear this indicator.

Table 5-1. System Fault Indications

FAULT INDICATION	EXPLANATION/REMEDY
Laser does not start (no output power)	Refer to Chart 1
Interlocks	Refer to Chart 2
FAULT indicator is on or flashing	Refer to faults in Charts 5, 6, and 7.
Low output power	Refer to Chart 3
Unstable output power	Refer to Chart 4
DUTY CYCLE indicator on	When illuminated indicates that the pulse width is greater than 1000 µs, or operating at a duty cycle of 60% or greater. Reduce the duty cycle to less than 60% or the pulse width to less than 1000 µs and this light should no longer be illuminated. This warning will be illuminated only when the fault is active.
VSWR indicator on	When illuminated indicates that the ratio of the reflected RF voltage to the forward RF voltage has exceeded a preset level. The warning light will be illuminated only when the fault is active. There are transient starting conditions that will occasionally exist and result in this indicator being momentarily illuminated. If the indicator is illuminated continuously, then this indicates a potential problem with the RF cable or the laser tube. the FAULT RESET switch on the front panel of the remote control unit will clear this indicator.
FORWARD indicator on	When illuminated indicates that the forward RF voltage to the laser tube has fallen below a preset value. This indicator will be illuminated only when the fault is active there are transient starting conditions that occasionally exist and result in the indicator being momentarily illuminated. If the indicator is being continuously this indicates a potential problem with the RF power supply. The FAULT RESET switch on the remote control unit will clear this indicator.
REFLECTED RF indicator on	When illuminated indicates that the reflected RF voltage from the tube and RF cable exceeds a preset value. This indicator will be illuminated only when the fault is active. There are transient starting the fault is active. There are transient starting conditions that will occasionally exist and result in this indicator being momentarily illuminated. If the indicator is being continuously illuminated then this indicates a potential problem with the RF cable or the laser tube. The FAULT RESET switch on the remote control unit will clear this indicator.
SHUTTER SENSE indicator is flashing SHUTTER FAULT indicator is on	Shutter is not opening or closing completely. If problem persists, replace shutter according to procedures in this chapter or return to Coherent service center.
HEAD COVER indicator is on	Refer to chart 5
HEAD THERMAL indicator is on	Refer to chart 6
WATER FLOW indicator is on	Refer to chart 7
The fault indications listed above are intended for use during normal operation or during performance of the procedures in this manual. During operation, it is normal for some of the indicators to be on.	

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Chart 1. Laser Does Not Start (No Output Beam)

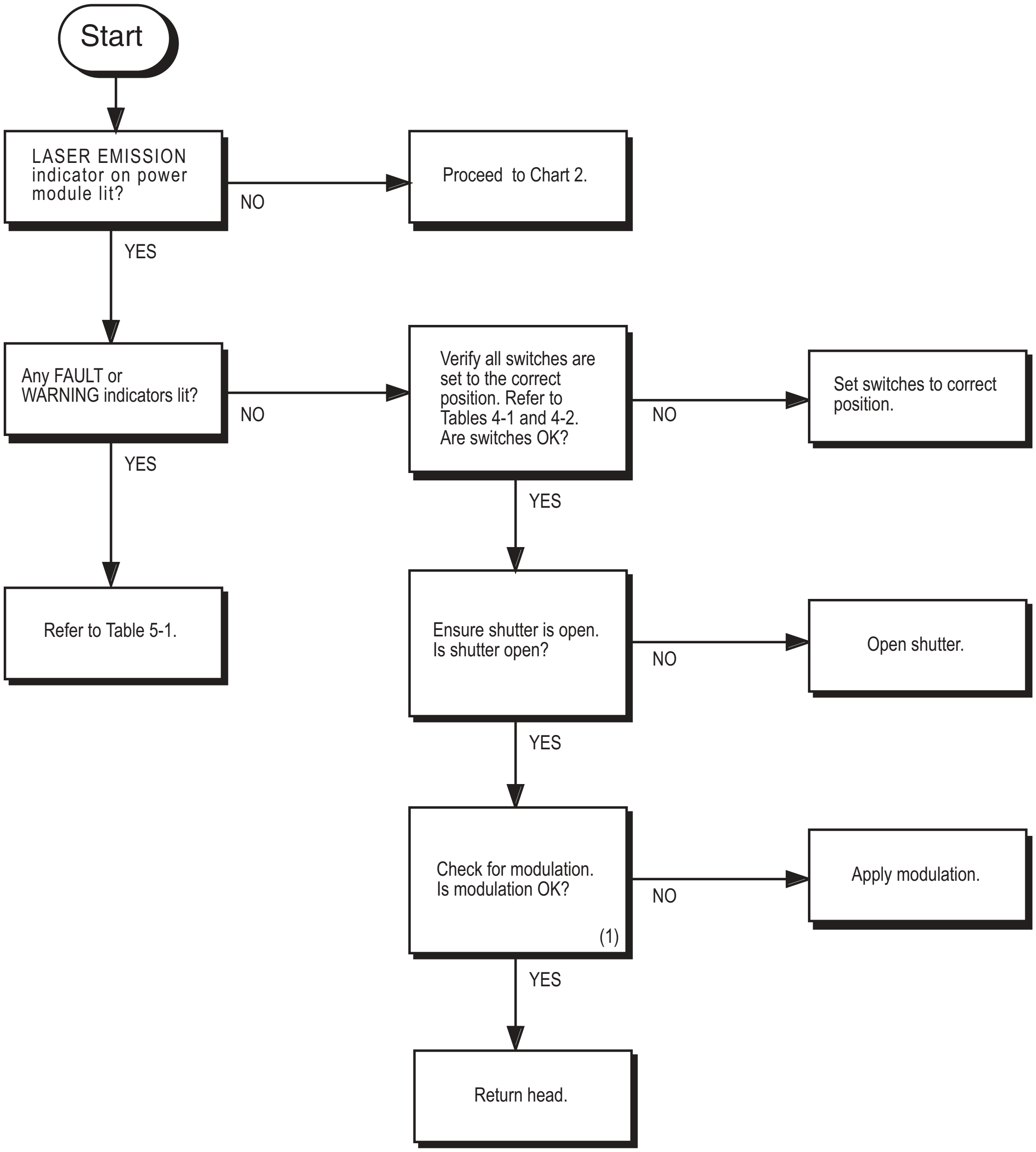
Start
LASER EMISSION indicator on power module lit?
NO
Proceed to Chart 2.
YES
Any FAULT or WARNING indicators lit?
NO
Verify all switches are set to the correct position. Refer to Tables 4-1 and 4-2. Are switches OK?
NO
Set switches to correct position.
YES
Refer to Table 5-1.
YES
Ensure shutter is open. Is shutter open?
NO
Open shutter.
YES
Check for modulation. Is modulation OK?
(1)
NO
Apply modulation.
YES
Return head.

Chart 1. Laser Does Not Start (No Output Beam) (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] The presence of modulation can be checked by connecting an oscilloscope to the SCOPE J17 connector on the rear of the remote control unit.

Chart 2. Interlocks

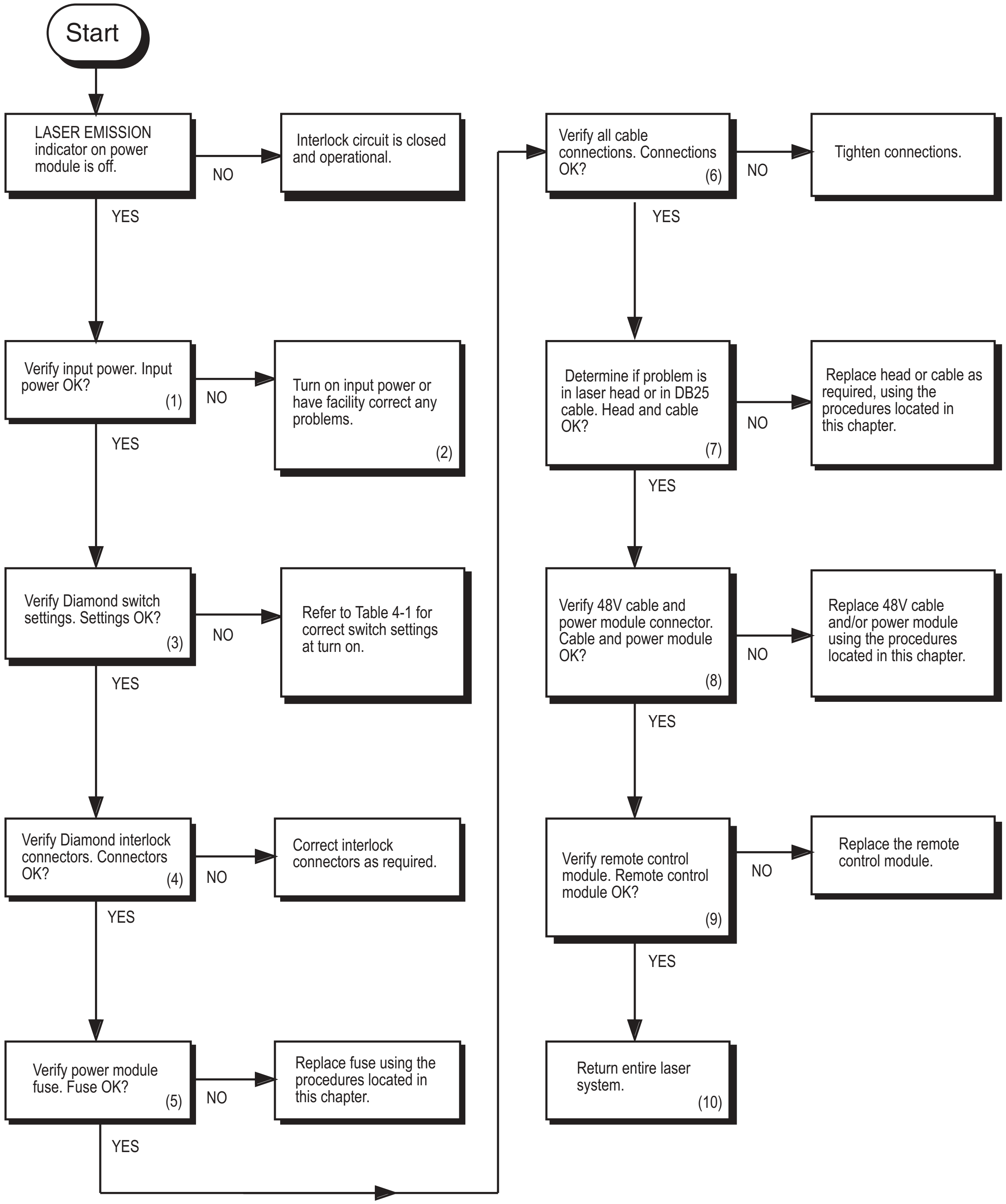
Start
LASER EMISSION indicator on power module is off.
NO
Interlock circuit is closed and operational.
YES
Verify input power. Input power OK? (1)
NO
Turn on input power or have facility correct any problems. (2)
YES
Verify Diamond switch settings. Settings OK? (3)
NO
Refer to Table 4-1 for correct switch settings at turn on.
YES
Verify Diamond interlock connectors. Connectors OK? (4)
NO
Correct interlock connectors as required.
YES
Verify power module fuse. Fuse OK? (5)
NO
Replace fuse using the procedures located in this chapter.
YES
Verify all cable connections. Connections OK? (6)
NO
Tighten connections.
YES
Determine if problem is in laser head or in DB25 cable. Head and cable OK? (7)
NO
Replace head or cable as required, using the procedures located in this chapter.
YES
Verify 48V cable and power module connector. Cable and power module OK? (8)
NO
Replace 48V cable and/or power module using the procedures located in this chapter.
YES
Verify remote control module. Remote control module OK? (9)
NO
Replace the remote control module.
YES
Return entire laser system. (10)

Chart 2. Interlocks (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] Input voltage to the Diamond must be between 208 VAC or 380 VAC, 50 to 60 Hz, 3 phase, with ground. Check the input voltage label on the rear panel of the power module to verify that the correct input voltage has been selected.

Use the procedure in Chapter Three to select the proper input voltage range.

[2] Verify input power as follows:

- Ensure the circuit breaker for facility power AC input is on.
- Ensure any facility power disconnects are turned on.
- Ensure the Diamond is receiving AC power.

[3] Diamond switch settings for initial turn on are listed in Table 3-3. For other configurations, switch settings are listed in Table 4-1 and Table 4-2.

[4] Refer to Table 4-6 for information on the power module interlock connector configuration and requirements. Refer to Table 4-8 for information on the remote control unit INTERLOCK+CONTROL J-11 connector configuration and requirements.

[5] Perform system shutdown and disconnect the power cable from facility power prior to checking the fuse for continuity.

[6] Refer to Figure 3-8 for the system interconnection diagram. Perform systems shutdown prior to checking cables for a secure fit.

[7] The following are optional checks to isolate the problem to the laser head or to the DB25 cable connecting the laser head:

- Turn off keyswitch on the power module.
- Disconnect The DB25 connector on the rear of the laser head, labelled CONTROL.
- Using a clip lead, or other conductor, connect pins 22 and 23 together. The numbers are typically visible near each pin in the connector.
- Turn on the keyswitch on the power module.
- If the LASER EMISSION indicator comes on, then the problem is in the laser head, and more specifically, the laser head board. Either return the laser head or replace the laser head board.
- If the problem is not remedied, then remove the lead between pins 22 and 23, and connect the cable to the connector labelled CONTROL on the laser head.
- If the LASER EMISSION indicator did not illuminate, turn off the keyswitch on the power module and remove the DB25 connector from the rear of the power module.
- In the DB25 connector on the rear panel of the power module, connect pins 22 and 23.
- Turn on the keyswitch on the power module.

Chart 2. Interlocks (Continued)

- If the LASER EMISSION indicator now illuminates, then the problem is in the DB25 cable. Replace this cable.
- If the LASER EMISSION indicator did not illuminate, proceed to the next step below.

[8] Another optional check to isolate the problem is in the cable supplying 48 V to the remote control unit or the connector on the power module.

- Turn off keyswitch on the power module.
- Disconnect the 48 V connector on the front panel of the power module.
- Using a clip lead, connect pins 2 and 3 in the connector on the end of the cable.
- Turn on the keyswitch on the power module.
- If the LASER EMISSION indicator now illuminates, then the problem is in the connector on the power module unit. Return it to the local service center for repair.
- If the LASER EMISSION indicator still does not illuminate, remove this cable from the remote control unit at the connector labelled 48V DC on the rear panel.
- Turn off the keyswitch on the power module and carefully connect pins 2 and 3 on the rear panel of the remote control unit.
- Turn on the keyswitch on the power module.
- If the LASER EMISSION indicator now illuminates, then the 4 pin cable to the remote control unit is faulty and needs to be replaced.

[9] Another optional test is to see if the problem is in the remote control unit. As a warning, this test requires shorting more than one set of pins.

- Turn off the keyswitch on the front panel of the power module.
- Remove the 37 pin connector from the rear panel of the REMOTE CONTROL UNIT.
- Connect the following pins in the DB37 connector at the end of the cable, pin 30 to 36, pin 32 to 37, pin 32 to 33.
- Turn on the keyswitch.
- If the LASER EMISSION indicator is illuminated, the problem is in the remote control unit. Return this to the authorized Coherent repair center.
- If the LASER EMISSION indicator is not illuminated, Then turn off the keyswitch and remove the DB37 cable from the power module.
- Make the same connections as noted above, but in the DB37 connector on the front panel of the power module.
- Turn on the keyswitch.
- If the LASER EMISSION indicator is illuminated, then the problem is in the DB37 cable assembly. Replace this cable.

[10] See page ii at the beginning of this manual for instructions on returning the laser system to Coherent or your local Coherent representative.

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Chart 3. Low Output Power

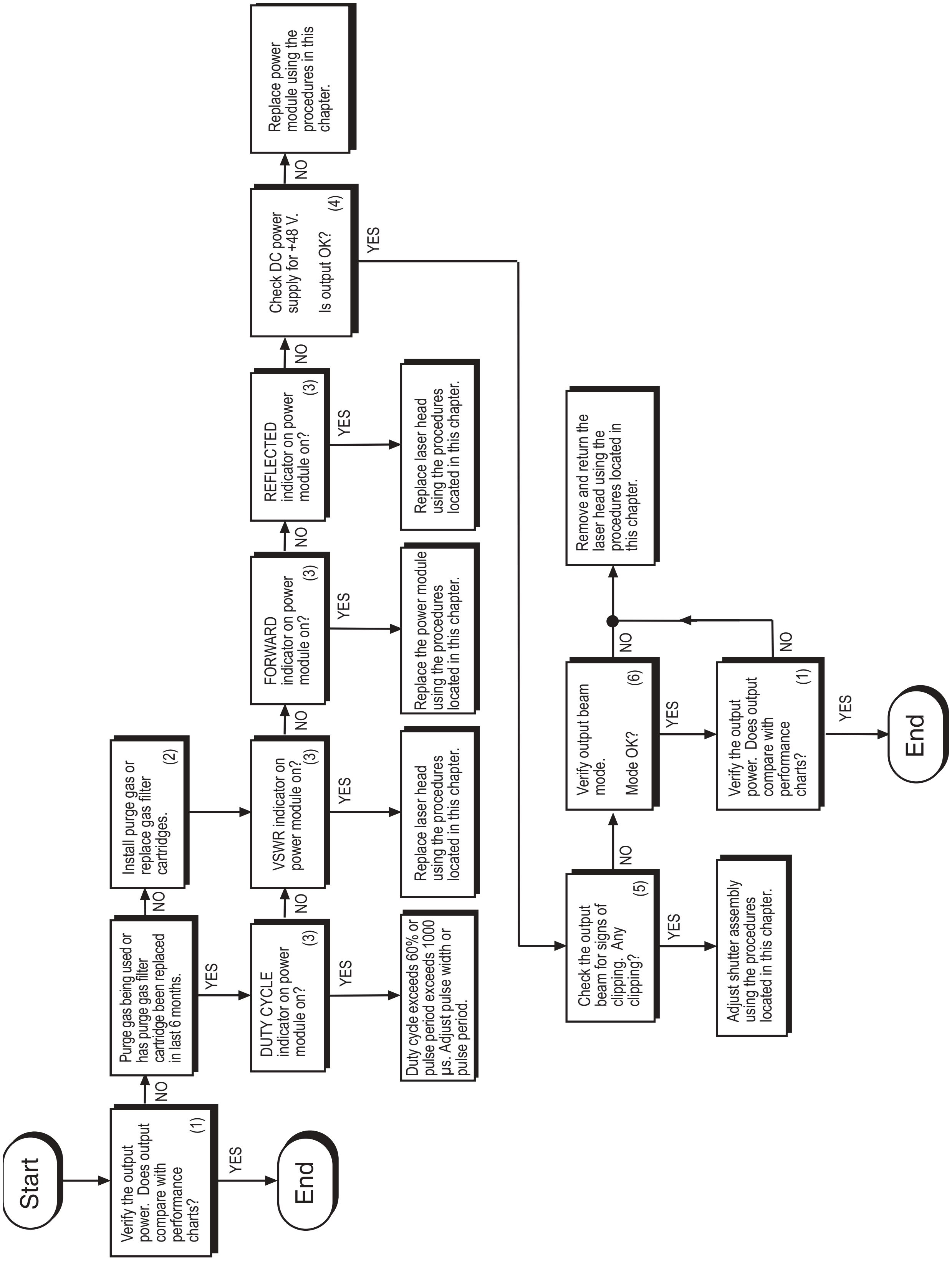
Start
Verify the output power. Does output compare with performance charts? (1)
YES
End
NO
Purge gas being used or has purge gas filter cartridge been replaced in last 6 months.
NO
Install purge gas or replace gas filter cartridges. (2)
YES
DUTY CYCLE indicator on power module on? (3)
YES
Duty cycle exceeds 60% or pulse period exceeds 1000 µs. Adjust pulse width or pulse period.
NO
VSWR indicator on power module on? (3)
YES
Replace laser head using the procedures located in this chapter.
NO
FORWARD indicator on power module on? (3)
YES
Replace the power module using the procedures located in this chapter.
NO
REFLECTED indicator on power module on? (3)
YES
Replace laser head using the procedures located in this chapter.
NO
Check DC power supply for +48 V.
Is output OK? (4)
NO
Replace power module using the procedures in this chapter.
YES
Check the output beam for signs of clipping. Any clipping? (5)
YES
Adjust shutter assembly using the procedures located in this chapter.
NO
Verify output beam mode.
Mode OK? (6)
NO
Remove and return the laser head using the procedures located in this chapter.
YES
Verify the output power. Does output compare with performance charts? (1)
NO
YES
End

Chart 3. Low Output Power (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] Verify the output power as follows:

- If the laser is off, perform the startup procedures.
- Close the shutter by setting the SHUTTER OPEN/CLOSED switch on the remote control unit to CLOSED.
- Turn on the aiming beam using the AIMING BEAM switch.
- Use the aiming beam to position the power meter in front of the output aperture.
- Open the shutter and verify the output power using the charts on Figure 4-4.

The following must be considered when evaluating system output:

- An accurate power meter capable of handling the output power must be used. The power meter should be verified using a known good source or be calibrated on a periodic basis.
- Note that output power may degrade with tube age. For example, a tube with 4000 operating hours may not have the same output power as the same tube with 300 hours.

[2] Purge gas is extremely important to use in humid environments. It can also increase the time between cleaning of optics in a purged beam delivery system.

[3] If the DUTY CYCLE indicator is on, then the modulation selected is greater than 60% or the pulse width is greater than 1000 µs. Reduce the duty cycle to 60% or less and make sure pulse width is less than 1000 µs to eliminate this problem. Reduce the duty cycle by lowering the pulse width setting or increasing the pulse period setting, or by lowering a combination of both settings.

[4] The VSWR, FORWARD, and REFLECTED warning indicators can be triggered on by a transient event. Observe the warning light while the laser is operating. If the warning indicator is on continuously, then proceed with the evaluation to determine if the low power is due to the laser head or power module. If the warning extinguishes then continue with the troubleshooting guide for other potential sources of power instability. See Table 5-1 for details of the warning indicators. Appropriate action is indicated.

[5] Check the function of the DC power supply in the following fashion: This functional check requires a laser power meter (or a power meter and mechanical chopper) that can measure up to 400 W power level. With the laser turned off, place a power meter in the beam path. Select the LOCAL mode with a PULSE PERIOD of 1000 µsec and a pulse width of 200 µsec. Open the shutter, then turn the laser on and record the laser output power. Turn the laser off and select a pulse width of 590 µsec. Again, turn the laser on and record the output power. The DC power supply in the power module is functioning correctly if the ratio of the output powers (590 µsec power ÷ 200 µsec power) is greater than 2.0. If the ratio of the output powers is less than this, return the power module to Coherent or your Coherent representative for repair.

Chart 3. Low Output Power (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[6] If the shutter is improperly adjusted or is not fully open or fully closed, it could clip (partially block) the output beam. This condition can be checked by inspecting the mode card for signs of clipping. Also check the SHUTTER OPEN indicator on the remote control unit. A flashing LED indicates that the shutter is not completely open or closed. In this case, replace the shutter assembly.

[7] Check mode quality as follows:

- Close the shutter by setting the SHUTTER OPEN/CLOSED switch on the remote control unit to CLOSED.
- Set the MODULATION CONTINUOUS/OFF/MOMENTARY switch on the remote control unit to OFF.
- A low output power setting (200 µs pulse width, 6000 µs pulse period) of 25 to 35 Watts is recommended.
- Turn on the aiming beam by setting the AIMING BEAM switch on remote control unit to OPEN.
- Use the aiming beam to position a thermal alignment card approximately 3 meters in front of the output beam aperture. A thermal image plate can also be used to inspect mode.
- Open the shutter by setting the SHUTTER OPEN/CLOSED switch on remote control unit to OPEN.
- Toggle the MODULATION CONTINUOUS/OFF/MOMENTARY switch to the MOMENTARY position. The output beam will mark the mode card. Inspect the card for asymmetric mode.

  If there are rings or partial rings surrounding the central beam, the laser beam is misaligned to the optical system and might require re-alignment. In this case, the laser head must be returned to the factory.

  If there are signs of clipping, proceed to the next step.

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Chart 4. Unstable Output Power

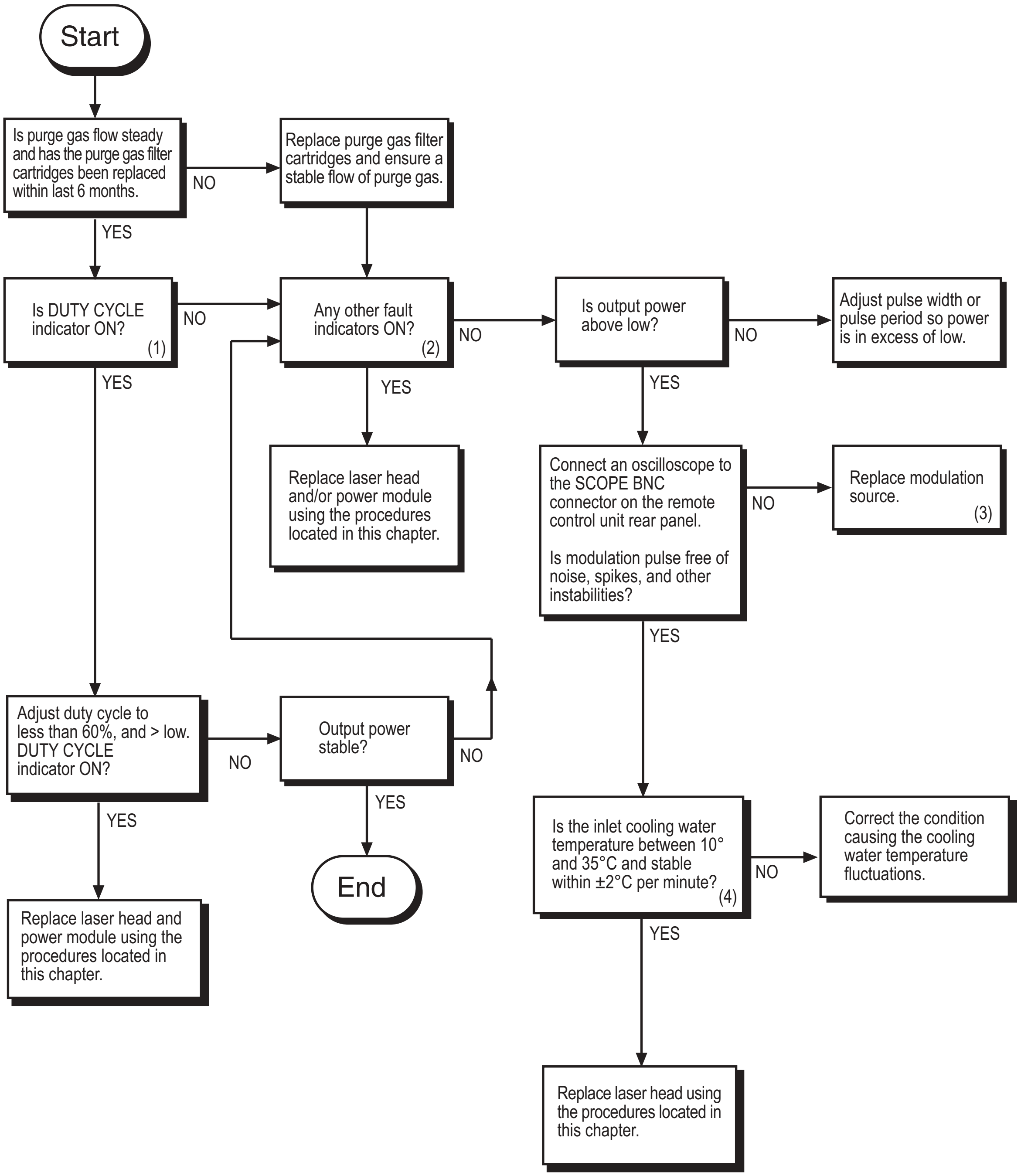
Start
Is purge gas flow steady and has the purge gas filter cartridges been replaced within last 6 months.
NO
Replace purge gas filter cartridges and ensure a stable flow of purge gas.
YES
Is DUTY CYCLE indicator ON? (1)
NO
Any other fault indicators ON? (2)
NO
Is output power above low?
NO
Adjust pulse width or pulse period so power is in excess of low.
YES
YES
Replace laser head and/or power module using the procedures located in this chapter.
YES
Connect an oscilloscope to the SCOPE BNC connector on the remote control unit rear panel.
Is modulation pulse free of noise, spikes, and other instabilities?
NO
Replace modulation source. (3)
YES
Adjust duty cycle to less than 60%, and > low. DUTY CYCLE indicator ON?
NO
Output power stable?
NO
YES
End
YES
Replace laser head and power module using the procedures located in this chapter.
Is the inlet cooling water temperature between 10° and 35°C and stable within ±2°C per minute? (4)
NO
Correct the condition causing the cooling water temperature fluctuations.
YES
Replace laser head using the procedures located in this chapter.

Chart 4. Unstable Output Power (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

Note that the RESET switch on the remote control unit must be pressed to clear the DUTY CYCLE, FORWARD, REFLECTED, and VSWR indicator fault lights.

[1] If the DUTY CYCLE indicator is on, then the modulation selected is greater than 60% or the pulse width is greater than 1000 µs. Reduce the duty cycle to 60% or less and make sure pulse width is less than 1000 µs to eliminate this problem. Reduce the duty cycle by lowering the pulse width setting or increasing the pulse period setting, or by lowering a combination of both settings.

[2] The VSWR, FORWARD, and REFLECTED warning indicators can be triggered on by a transient event. Observe the warning light while the laser is operating. If the warning indicator is on continuously, then proceed with the evaluation to determine if the low power is due to the laser head or power module. If the warning extinguishes then continue with the troubleshooting guide for other potential sources of power instability. See Table 5-1 for details of the warning indicators. Appropriate action is indicated.

[3] If the MOD SELECT switch on the remote control unit is set to EXT, replace the device connected to the EXT PULSE GEN connector on the remote control unit rear panel. If the power is stable, then replace the external pulse generator.

If the MOD SELECT switch is set to the LOCAL position, then replace the remote control unit.

[4] There are two common methods of determining water temperature. A simple, economical, and most accurate method is a multimeter temperature accessory attached to a water hose fitting. The alternate method which is described below consists of touching the inlet water hose.

Check inlet water temperature by touching the cooling water inlet hose attached to the laser head. If the hose is warm to the touch, inlet water may be too hot for stable output power. Request that facilities personnel correct this problem.

Chart 5. HEAD COVER Indicator is On

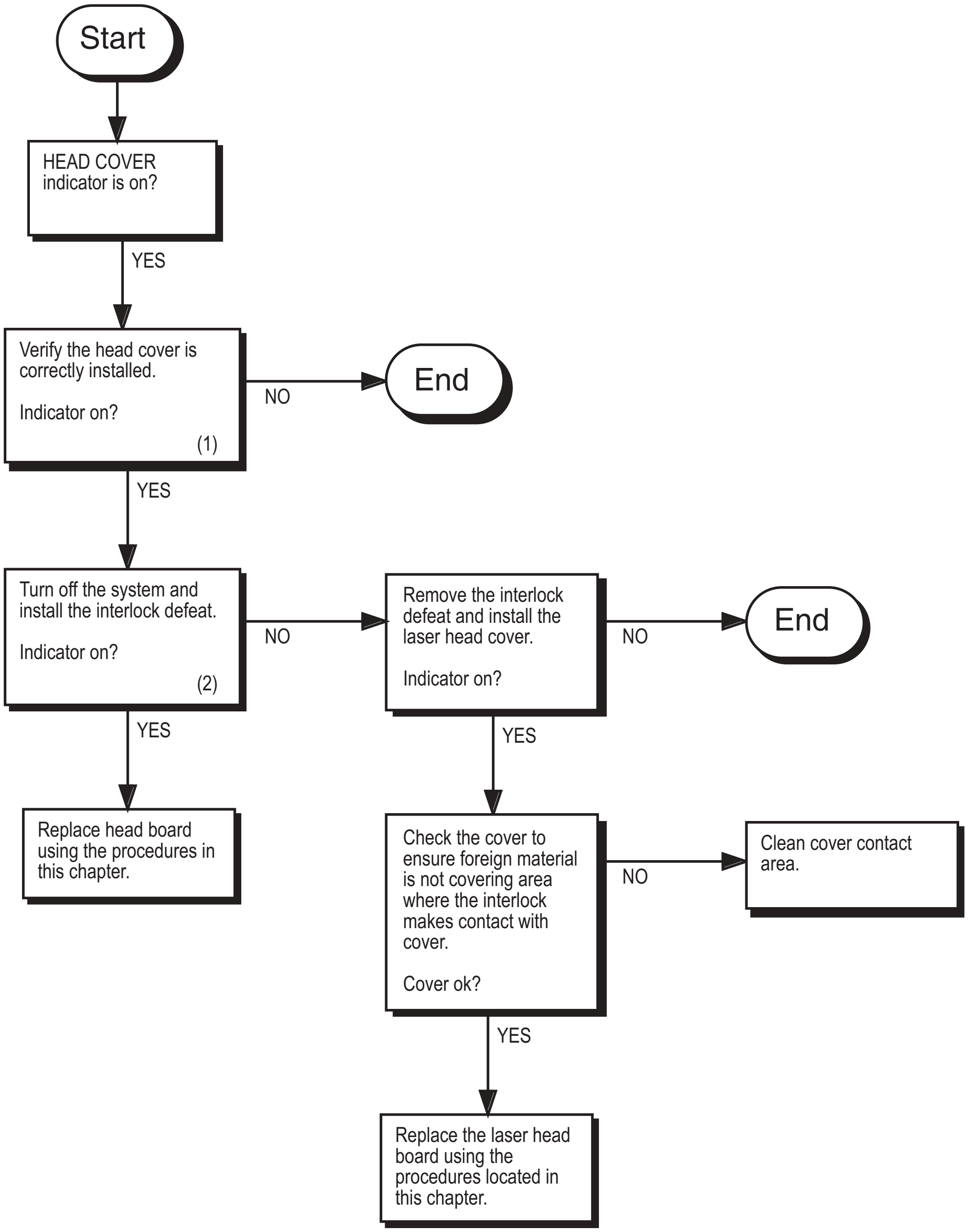
Start
HEAD COVER indicator is on?
YES
Verify the head cover is correctly installed.
Indicator on?
(1)
NO
End
YES
Turn off the system and install the interlock defeat.
Indicator on?
(2)
NO
Remove the interlock defeat and install the laser head cover.
Indicator on?
NO
End
YES
Replace head board using the procedures in this chapter.
YES
Check the cover to ensure foreign material is not covering area where the interlock makes contact with cover.
Cover ok?
NO
Clean cover contact area.
YES
Replace the laser head board using the procedures located in this chapter.

Chart 5. HEAD COVER Indicator is On (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

Note that the RESET switch on the remote control unit must be pressed to clear the HEAD COVER indicator fault light.

---

[1] The laser head cover must be correctly installed for normal operation. If the laser head cover has been removed for maintenance, an interlock defeat must be installed. In either case, proceed as follows:

- Perform system shutdown in accordance with the shutdown procedures in Chapter Four, Daily Operation.
- Ensure the laser head cover is firmly seated and all 40 screws are securely in place.
- Perform system startup in accordance with the startup procedures in Chapter Four.

[2] Perform system shutdown in accordance with the shutdown procedures in Chapter Four, Daily Operation.

- Remove the laser head cover and install the interlock defeat (located in the maintenance kit) on the laser head board (Figure 5-7). Turn on the system.

Chart 6. HEAD THERMAL Indicator is On

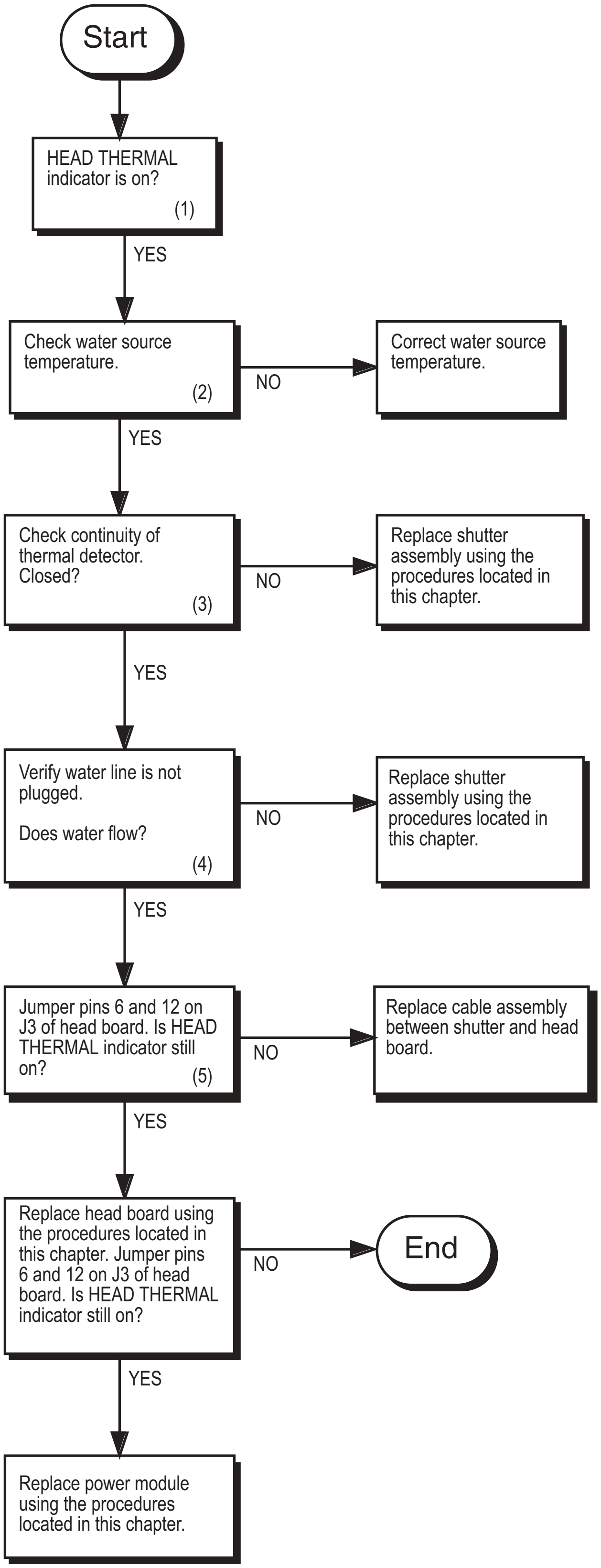
Start
HEAD THERMAL indicator is on? (1)
YES
Check water source temperature. (2)
NO
Correct water source temperature.
YES
Check continuity of thermal detector. Closed? (3)
NO
Replace shutter assembly using the procedures located in this chapter.
YES
Verify water line is not plugged.
Does water flow? (4)
NO
Replace shutter assembly using the procedures located in this chapter.
YES
Jumper pins 6 and 12 on J3 of head board. Is HEAD THERMAL indicator still on? (5)
NO
Replace cable assembly between shutter and head board.
YES
Replace head board using the procedures located in this chapter. Jumper pins 6 and 12 on J3 of head board. Is HEAD THERMAL indicator still on?
NO
End
YES
Replace power module using the procedures located in this chapter.

Chart 6. HEAD THERMAL Indicator is On (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

Note that the RESET switch on the remote control unit must be pressed (with the cooling water turned on) to clear the HEAD THERMAL indicator fault light.

[1] The HEAD THERMAL indicator monitors excessive temperature of the water cooled shutter since the Diamond continues to lase when the shutter is closed. The shutter assembly must be able to dissipate this heat. The possible causes for this indicator to be On are:

- The water source is too warm. This chart assumes the WATER FLOW indicator is Off. If the WATER FLOW indicator is on, troubleshoot that fault prior to proceeding.
- Defective thermal switch.
- Defective head board in laser head.
- Defective DDI board in the power module.

During a cold start, heat build-up could not cause the HEAD THERMAL indicator to remain on. In this case, a thermal switch (located in the shutter assembly) malfunction or a head board, or the DDI circuit board fault would be the most likely cause. The thermal switch is verified in paragraph [3] below.

If the system shuts down during operation with the shutter closed, the problem could be due to overheating. In this case, allow the system to cool down while checking the cooling water temperature as described below.

[2] There are two common methods of determining water temperature. A simple, economical, and most accurate method is a multimeter temperature accessory attached to a water hose fitting. The alternate method which is described below consists of touching the inlet water hose.

Check inlet water temperature by touching the cooling water inlet hose attached to the laser head. If the hose is warm to the touch, inlet water may be too hot for the system to turn on, or the system may shut down after a short operating period. Request that facilities personnel correct this problem. Refer to the specifications for correct inlet water temperature.

[3] Perform system shutdown in accordance with the shutdown procedures in Chapter Four, Daily Operation.

- Remove the electrical connector (Figure 5-5, item 2) from the shutter assembly. Check for a closed circuit between pins 6 and 12 (–) of the connector on the shutter assembly. This is the thermal switch in the shutter assembly. The switch is normally closed (HEAD THERMAL indicator Off). According to the procedure located in this chapter.

Chart 6. HEAD THERMAL Indicator is On (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[4] Perform system shutdown in accordance with the shutdown procedures listed in this manual. Remove the laser head cover and disconnect (have paper towels on hand) the water line at the tee on Figure 5-2, item 1. Plug the Tee connector and turn on the cooling water supply. Direct the water line into a bucket to determine if the water line is plugged. If the line is plugged, try reversing the water flow to clear the obstruction. If this does not solve the problem, then replace the shutter assembly.

If the water lines are plugged, determine the water hardness and particulate level to make sure that they are within the levels specified in Table 3-1.

[5] Perform system shutdown in accordance with the shutdown procedure in Chapter Four, Daily Operations.

- Remove the laser head cover and remove the 15 pin connector at J3 on the head board. This is the cable assembly that connects the head board to the shutter assembly.
- Place a jumper between pins 6 and 12 on the connector on the head board. Turn on the system and observe the status of the HEAD THERMAL indicator on the power module. If it is still on, then the problem is in the head board or the DDI board located in the power module. Replace the laser head board according to the procedure located in this chapter.

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Chart 7. WATER FLOW Indicator is On

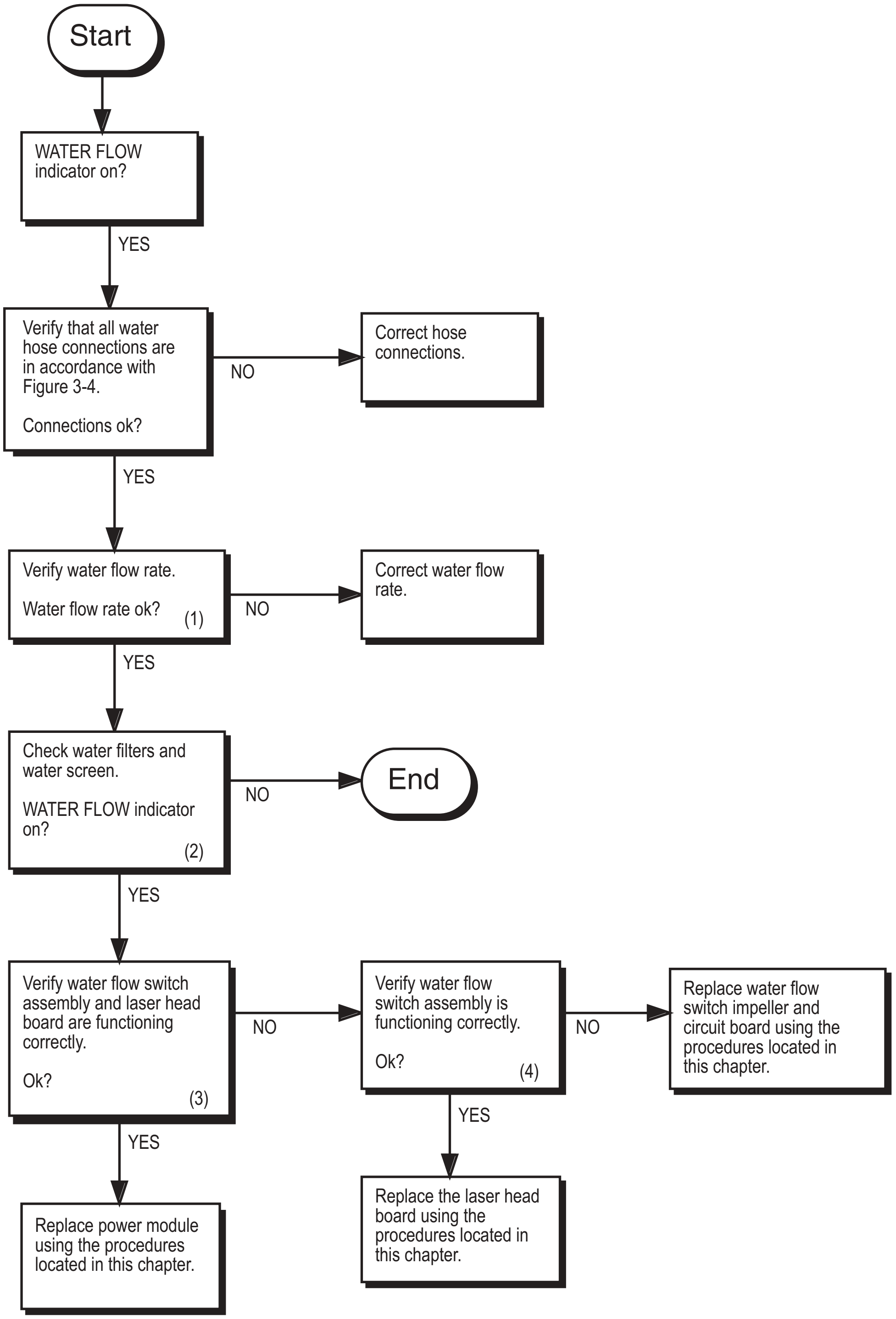

Start
WATER FLOW indicator on?
YES
Verify that all water hose connections are in accordance with Figure 3-4.
Connections ok?
NO
Correct hose connections.
YES
Verify water flow rate.
Water flow rate ok? (1)
NO
Correct water flow rate.
YES
Check water filters and water screen.
WATER FLOW indicator on? (2)
NO
End
YES
Verify water flow switch assembly and laser head board are functioning correctly.
Ok? (3)
NO
Verify water flow switch assembly is functioning correctly.
Ok? (4)
NO
Replace water flow switch impeller and circuit board using the procedures located in this chapter.
YES
Replace power module using the procedures located in this chapter.
YES
Replace the laser head board using the procedures located in this chapter.

Chart 7. WATER FLOW Indicator is On (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

Note that the RESET switch on the remote control unit must be pressed (with the cooling water supply turned on) to clear the WATER FLOW indicator fault light.

[1] There are two common methods of determining water flow rate. The simplest and most accurate method is to install an in-line flow meter in the return line. The alternate method which is described below uses a calibrated water bucket.

When using facility water for cooling the laser, check cooling water flow rate as follows:

- Set the MODULATION CONTINUOUS/OFF/MOMENTARY switch on the remote control unit to Off.
- Set the SHUTTER OPEN/CLOSED switch to CLOSED.
- Turn off water flow to the system.
- Disconnect the water hose from facility drain. The other end of this hose is connected to the TO DRAIN cooling water connector on the power module.
- Use a flow meter to determine the water flow rate. If a flow meter is not available, perform the next two steps to determine the flow rate.
- Calibrate a bucket in one liter or one gallon increments.
- Direct the hose into the bucket. Turn on water flow and measure the time it takes to fill the bucket to a convenient calibration mark. The minimum flow rate is 1.5 gallon per minute (5.7 liters/minute).

If water flow rate is below or only slightly above (+10%) specification, increase the water flow. If water flow fluctuates, investigate water uses which are connected to your water source. For example, a device on the same water line may cause a sudden drop in supply water flow.

If the laser system is connected to a closed-loop cooling system, the water flow rate test may not give a valid result. If the drain back-pressure of the closed-loop system is too high, the water flow rate through the laser system will not be as high as your measurement indicates. In this case, increase the input pressure of water going to the laser system.

An alternate method for determining if a closed-loop cooling system is causing the problem is to connect the laser system to a facility water supply to determine if this corrects the problem.

Chart 7. WATER FLOW Indicator is On (Continued)

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[2] Turn off the cooling water and check any water filters in the cooling system. If they appear dirty, replace the filter. Turn on the cooling water, then press the RESET switch on the remote control unit to determine if the fault can be cleared.

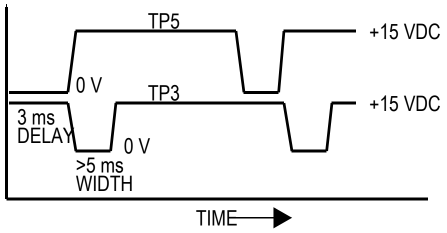
The in-line water screen should also be checked. Refer to Figure 5-1 and Figure 5-2 for the location of the water filter screen. Procedures for removing and cleaning the water filter screen are located in this chapter. Turn on the cooling water and press the RESET switch on the remote control unit to determine if the fault can be cleared.

[3] At this point, it has been determined that the water flow rate is above 1.5 gpm, water flowing through the system is in the correct direction, and that all water filters and screens are clean. The remaining steps check the circuit boards and the water flow switch assembly.

- Perform system shutdown in accordance with the shutdown procedures in Chapter Four, Daily Operation.
- Remove the laser head cover and install the interlock defeat (located in the maintenance kit) in the position shown on Figure 5-7.
- Connect a voltmeter to TP4 on the laser head board. The location of the laser head board and TP4 are shown on Figure 5-1 and Figure 5-7.
- Perform system startup in accordance with the startup procedures in Chapter Four, Daily Operation.
- Verify that when the water flow rate is above 1.5 gpm, the signal at TP4 is low (ground) and is high (+5V) when the flow rate is lower than 1.5 gpm.

  If correct, the water flow switch assembly and the laser head board are functioning correctly. If the indication is incorrect, R1 can be adjusted; however, this potentiometer is adjusted at the factory and further adjustment is not normally required. Proceed to the next step to verify that the water flow switch assembly is functioning correctly prior to adjusting R1.

[4] Connect an oscilloscope to TP3 and TP5 to observe the input to the laser head board from the water flow switch assembly. The correct indication is shown below.



If the indication is incorrect, replace the water flow switch circuit board and the impeller using the procedures located in this chapter.

If the indication is correct, replace the laser head board using the procedures located in this chapter. Adjust R1 to set the water flow rate trip point (as described under paragraph 3 above) on the laser head board prior to replacing the board.

Replacement Procedures

If the item to be replaced will be returned to the supplier, use the original shipping containers. In general, the supplier is not responsible for damage incurred during shipping and the carrier is not responsible for improper packing.

Laser Head Removal

Do not remove the laser head unless instructed to do so in the troubleshooting procedures.

Refer to Figure 4-9 for the location of the laser head connectors.

1. Perform system shut-down in accordance with the shut- down procedures in Chapter Four, Daily Operation.
2. Disconnect the power module line cable from the facility power outlet.
3. Disconnect the cable from the laser head connector labeled CONTROL.
4. Disconnect the cable from the laser head connector labeled RF.
5. Disconnect the nitrogen line from the PURGE connector.

Water in the laser head must be drained completely. Failure to do so can lead to damage due to freezing water during shipping or storage. This will void the warranty.

6. Use a bucket for water drainage and have a supply of paper towels on hand while disconnecting the water lines from the laser head water connector labeled WATER OUT and from the laser head water connector labeled WATER IN.
7. Remove as much water from the laser head as possible using pressurized air or by tilting the head several times. Install the water connector caps that were removed during installation to prevent residual water leakage during shipment. Install the beam tube seal into the beam exit aperture.

Power Module Removal

Do not remove the power module unless instructed to do so in the troubleshooting procedures.

Refer to Figure 4-10 for the location of the power module and connectors.

1. Perform system shut-down in accordance with the shut-down procedures in Chapter Four, Daily Operation.
2. Disconnect the power module line cable from the facility power outlet.

Use a bucket for water drainage and have a supply of paper towels on hand while disconnecting the two water lines.

---

3. Disconnect the following water lines from the power module.
    - From the TO DRAIN hose connector
    - From the WATER SUPPLY hose connector
    - From the TO LASER hose connector
    - From the FROM LASER hose connector
4. If installed, disconnect the user cable from the INTERLOCK connector.
5. Disconnect the following electrical cables:
    - From the CONTROLLER connector
    - From the 48 V connector
    - From the RF LASER connector
    - From the LASER connector

Water in the power module must be drained completely. Failure to do so can lead to damage due to freezing water during shipping or storage. This will void the warranty.

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6. Remove as much water from the power module as possible by tilting the unit several times or by using pressurized air. Install the water connector caps that were removed during installation to prevent residual water leakage during shipment.

Laser Head/ Power Module Installation

Installation is the reverse of the above removal procedures. Do not turn on laser system power until the following has been performed.

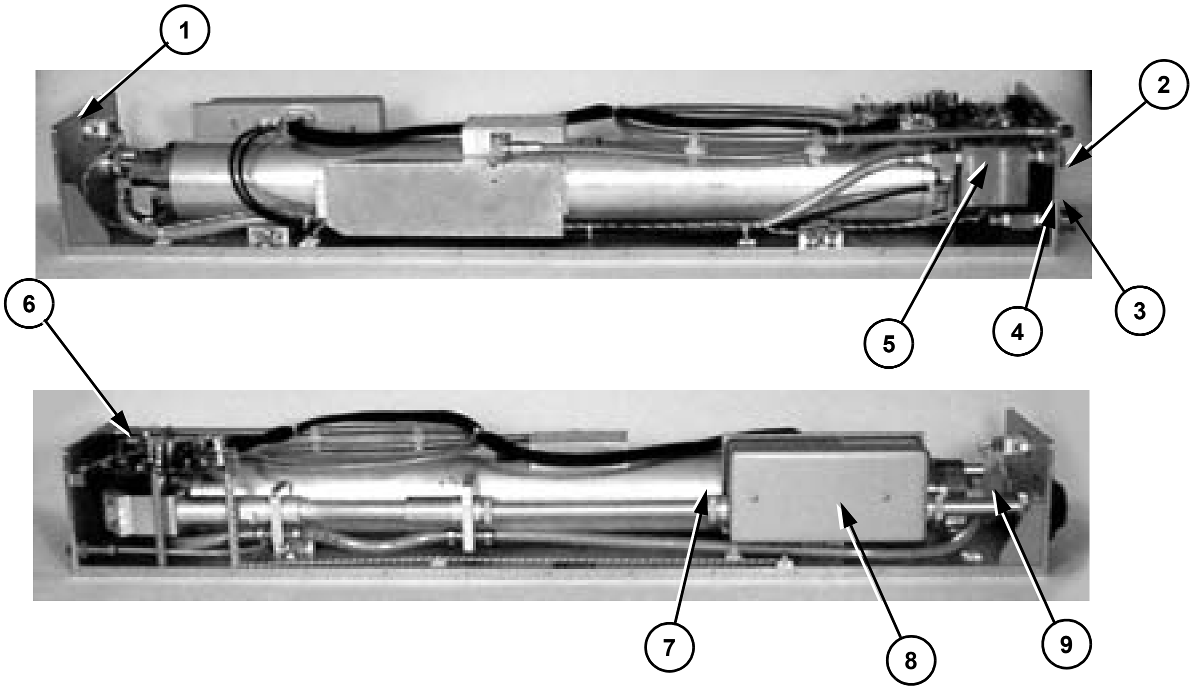
- Ensure all electrical and cooling water line connections are complete.
- Verify that there are no water leaks as follows:
  - √ Open the water drain.
  - √ Slowly open the water supply.
  - √ With the water supply pressure and water line differential pressure in accordance with Table 3-1, check all connections for leaks.
- Install the laser head cover.
- Ensure the laser system is fully assembled.
- Ensure the remote control unit switches are set in accordance with Table 4-1 and Table 4-2.

Perform the startup procedures in Chapter Four, Daily Operation.

Water Flow Switch Removal

The water flow switch is located in the laser head (Figure 5-1 and Figure 5-2). Do not remove the water flow switch unless instructed to do so in the troubleshooting procedures.

1. Perform system shut-down in accordance with the shut-down procedures in Chapter Four, Daily Operation.
2. Remove 40 Phillips head screws securing the laser cover and remove the cover.
3. Use a bucket for water drainage and have a supply of paper towels on hand while disconnecting the water lines.
4. Disconnect the laser head inlet and outlet water lines (Figure 4-10) from the power module.
5. Remove as much water from the laser head as possible using pressurized air or by tilting the head several times.
6. Gently rotate the water flow switch assembly 90° so the small circuit board located on the bottom to the water flow switch is accessible (facing away from the laser).
7. Remove the six screws from the water flow switch assembly and remove the impeller.
8. Remove the circuit board from the water flow switch assembly.



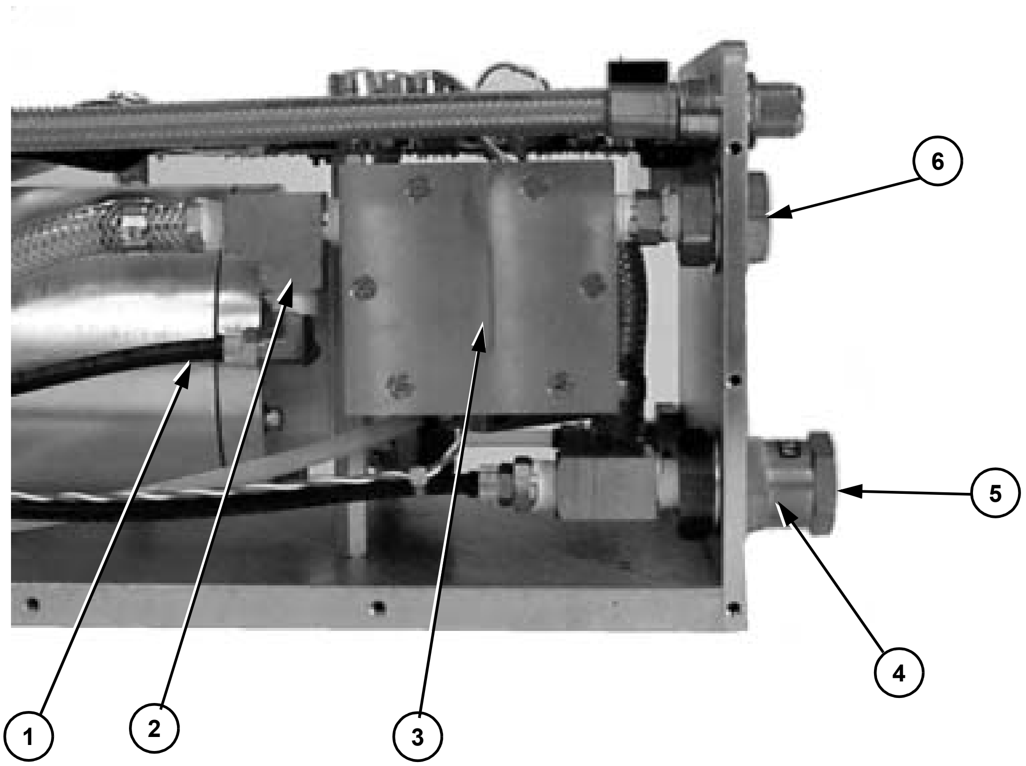
1. Emission indicator
2. Water outlet connector
3. Water inlet connector
4. Water filter screen
5. Water flow switch
6. Laser head board
7. Beam tube (shutter/output optic)
8. Shutter assembly
9. Beam tube (shutter/exit aperture)

Figure 5-1. Laser Head Component Locations

Water Flow Switch Installation

Installation is the reverse of removal. In replacing the cover of the flow switch, ensure that the O-ring is in the proper groove before securing the cover.

1. Use Teflon pipe tape when re-installing the water lines.
2. With power to the laser off and prior to installing the laser head cover, verify that there are no water leaks as follows:
    - Open the water drain.
    - Slowly open the water supply.
    - With the water supply pressure and water line differential pressure in accordance with Table 3-1, check all connections for leaks.
3. Install an interlock defeat (located in the maintenance kit) in the position indicated on Figure 5-7, item 6.



1.	Water line	4.	Water filter screen
2.	Water line tee connector	5.	Laser head inlet water hose connector
3.	Water flow switch	6.	Laser head outlet water hose connector

Figure 5-2. Water Flow Switch Replacement

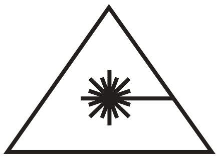
4. Using a flow meter or a calibrated bucket, adjust the water flow for 1.5 gpm.
5. Perform the startup procedures in Chapter Four, Daily Operation.
6. Monitor the WATER FLOW indicator on the power module. The indicator should be On when the water flow is less than 1.5 gpm and Off when the water flow is greater than 1.5 gpm.

   During this process, with the water flow above 1.5 gpm, toggle the RESET switch to turn off the WATER FLOW indicator

   If the indications are incorrect, adjust R31. Refer to Figure 5-7 for the location of R31.
7. Perform system shut-down. Remove the interlock defeat and re-install the laser head cover.

Emission Indicator Lamp Replacement

The laser emission indicator on the laser head consists of two incandescent light bulbs located behind a lens. When both bulbs are illuminated, then both words LASER and EMISSION on the lens are equally bright. If one bulb burns out then only one would will be illuminated and for safety factors it should immediately be replaced by the procedure that follows.



The emission indicator is located near the output aperture. Failure to turn off the system prior to performing the following procedure could result in injury.

1. Perform system shut-down in accordance with the shut-down procedure in Chapter Four, Daily Operation.
2. Remove the lens of the emission indicator by squeezing on the top and bottom edges and pulling out.
3. Pull out the failed bulb from the housing by pulling on the tab adjacent to the bulb. The bulb will come out in a carrier with the tab.
4. Remove the bulb from the carrier with the tab. Discard the bulb.
5. Install a new bulb in the carrier.
6. Replace the carrier in the housing.
7. Replace the lens by pushing it firmly in place.
8. Perform the system start-up according to the startup procedure in Chapter Four, Daily Operation.
9. Verify that both bulbs in the indicator are operational by observing that both words on the lens are evenly illuminated.

Shutter Assembly Removal

The shutter assembly is located in the laser head (Figure 5-1, Figure 5-4, and Figure 5-5). Do not remove the shutter assembly unless instructed to do so in the troubleshooting procedures.

1. Perform system shut-down in accordance with the shut-down procedures in Chapter Four, Daily Operation.
2. Remove 40 Phillips head screws securing the laser cover and remove the cover. The shutter assembly location is shown on Figure 5-1.

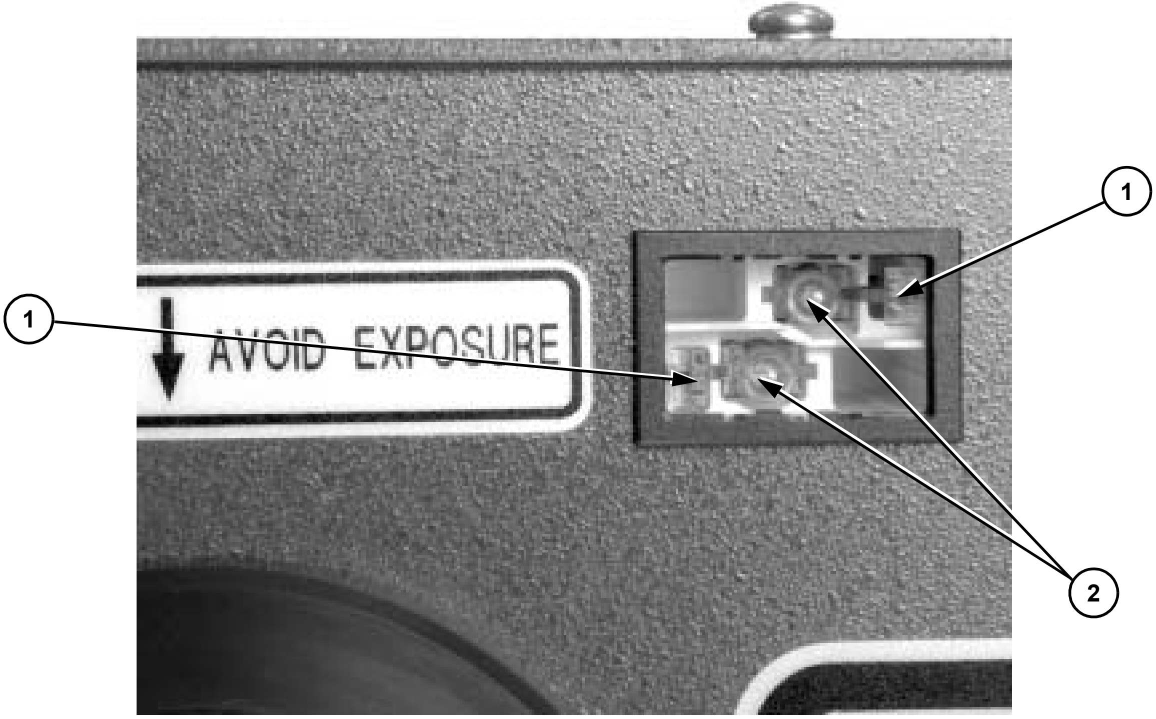
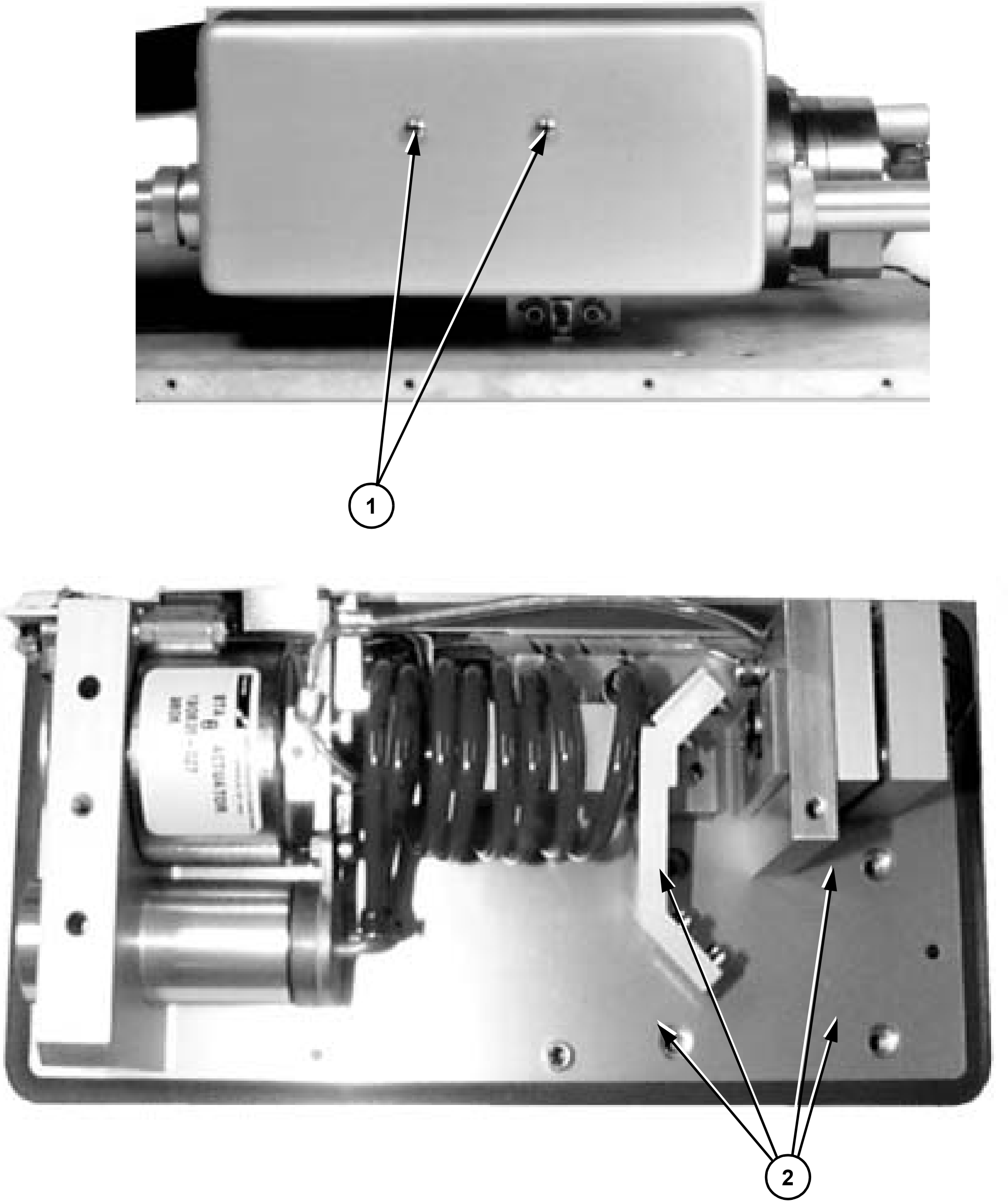


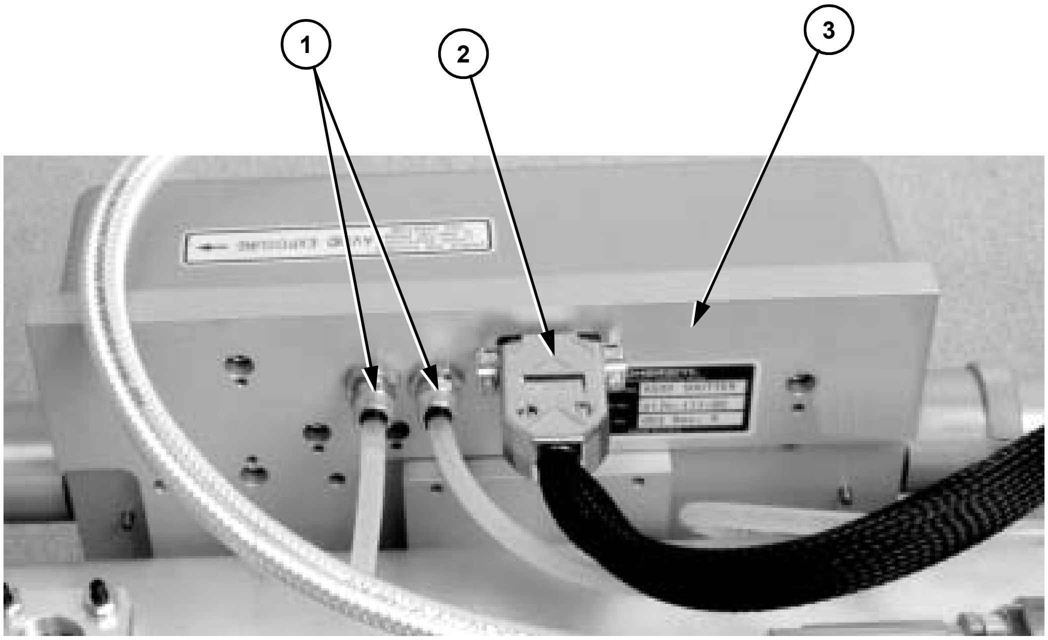
Figure 5-3. Emission Indicator Replacement

3. Remove the beam tubes (Figure 5-1, items 9 and 11). The beam tubes can be removed by unscrewing the knurled retaining rings on each end of the beam tube. The O-ring can then be re-positioned so that the beam tube can slide back for removal. Step 4 may need to be performed prior to removal of the shutter/output optic beam tube (Figure 5-1, item 9).
4. Remove the two screws securing the shutter assembly cover (Figure 5-4, item 1) and remove the cover.
5. Use a bucket for water drainage and have a supply of paper towels on hand while disconnecting the laser head water lines.
6. Disconnect the laser head inlet and outlet water lines (Figure 4-10) from the power module using the water hose quick disconnects.
7. Remove as much water from the laser head as possible using pressurized air or by tilting the head several times.
8. Disconnect the shutter assembly water lines (Figure 5-5, item 1).
9. Disconnect the nitrogen purge connector (Figure 5-5, item 4).
10. Disconnect the electrical connector (Figure 5-5, item 2).



1. Screws (2) securing shutter assembly cover
2. Screws (4) securing shutter assembly

Figure 5-4. Shutter Assembly Replacement



1. Cooling water lines
2. Electrical connector
3. Shutter assembly

Figure 5-5. Shutter Assembly Connections

11. Remove the four screws (Figure 5-4, item 2) and remove the shutter assembly.

Shutter Assembly Installation

Installation is the reverse of removal. However, the aiming beam must be aligned with the CO_2 beam after installation. Turn on the water source and adjust the water flow to ensure it is greater than the minimum flow rate. Check for and correct any water leaks at the water fittings to the shutter assembly. Do not replace the cover to the shutter assembly until later in this procedure.

Shutter Assembly Alignment

Perform shutter assembly alignment after replacing the shutter assembly.

1. Install an interlock defeat (located in the maintenance kit) in the position indicated on Figure 5-7, item 6.
2. Perform system start-up in accordance with the startup procedures in Chapter Four, Daily Operation. Do not apply modulation.

3. Turn on the aiming beam by setting the AIMING BEAM switch on the remote control unit to ON. Verify that the red aiming beam spot on the turning mirror of the shutter assembly is nearly at the center.

4. Adjust the laser for low power (typically using a pulse width of 100 µs and a pulse period of 6000 µs). Do not apply modulation. Ensure the shutter is closed.

5. Place a suitable target such as a thermal alignment card in the beam path at a distance of 3 meters from the front end plate of the laser head. Open the shutter. Briefly push the MODULATION switch to the MOMENTARY position in order to make a light burn in the surface of the target.

6. Close the shutter and check the location of the aiming beam relative to the burn spot of the beam on the target.

7. Adjust the horizontal and vertical tilt adjustment (Figure 5-6, items 1 and 2) screws to center the aiming beam on the burn mark. For both axes, a locking screw (Figure 5-6, item 4) must be loosened first before the adjustment is made.

8. Move the target so that it is 0.5 meters from the front end plate of the laser head. Open the shutter. Make another light burn in the target by pushing the MODULATION switch to the MOMENTARY position briefly.

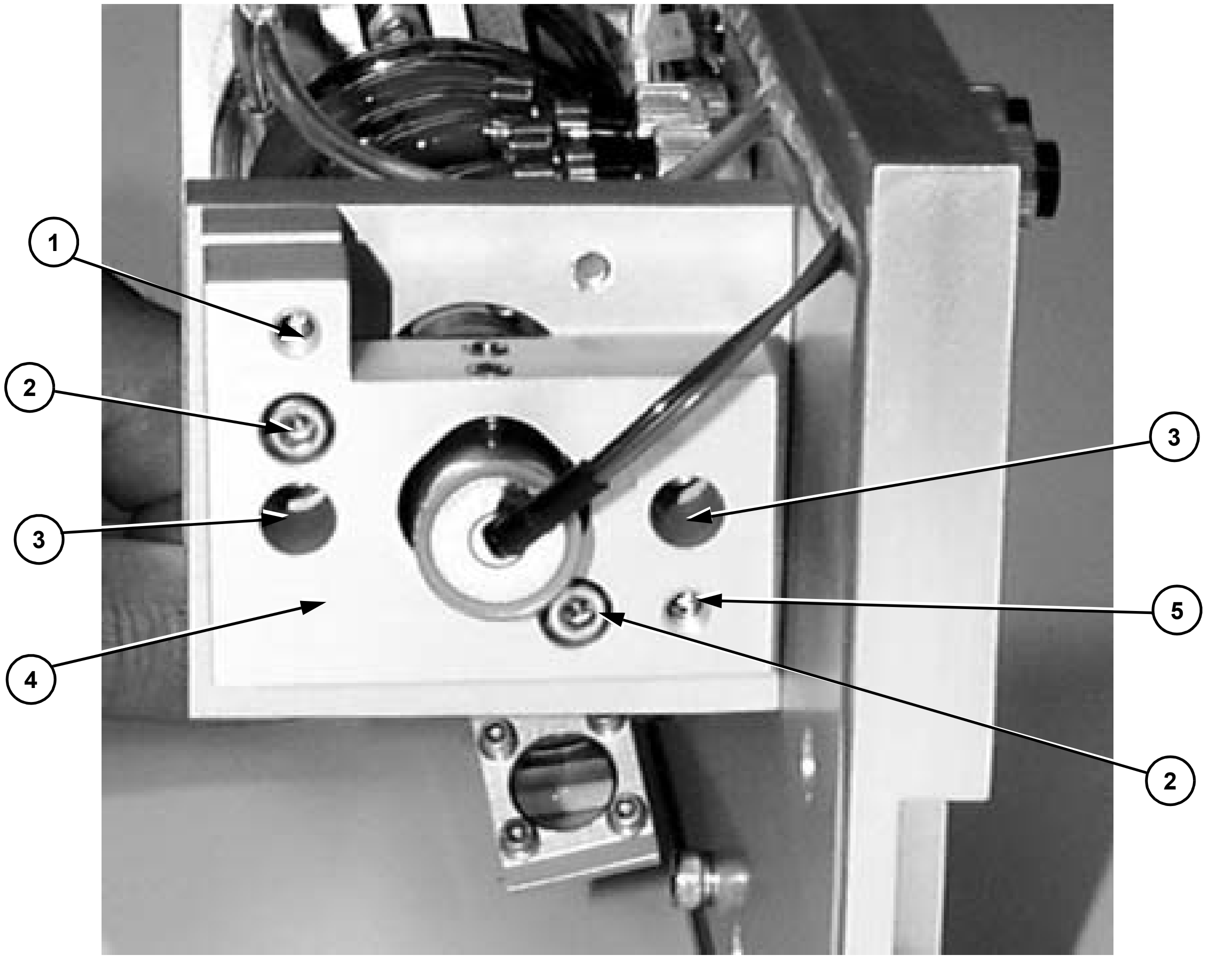
9. Close the shutter and check the location of the aiming beam relative to this new burn spot of the beam.

10. Gently move the translation adjust plate (Figure 5-6, item 3) to align the aiming beam spot to the burn spot. This plate can be translated left to right to move the beam in the vertical axis. Moving the plate in and out results in the beam moving in the horizontal axis.

11. Verify that the beam is still in alignment at the 3 meters distance by performing steps (3) to (5) above. Make the necessary adjustment to the vertical and horizontal tilt adjustment to bring the beams into alignment.

12. Verify that the beam is still in alignment at the 0.5 meter distance by performing steps (6) through (8). Again at this distance, only move the translation adjust plate to align the two beams.

13. Repeat this sequence of adjustment at 3 meters and 0.5 meters until no alignment of the aiming beam is required. This last check of the two beams being in alignment should be made with all locking hardware secured.



1. Vertical tilt angle adjust
2. Locking screws
3. Translation adjust plate locking screws (access holes)
4. Translation adjustment plate
5. Horizontal tilt angle adjust

Figure 5-6. Shutter Assembly Alignment

14. Perform system shut-down. Re-install the shutter assembly cover and the two beam tubes. Re-install the laser head cover using the 40 screws.

Laser Head Board Removal

The laser head board is located in the laser head (Figure 5-1 and Figure 5-7). Do not remove the head board unless instructed to do so in the troubleshooting procedures.

If necessary, label the cables during removal so they can be reinstalled correctly.

1. Perform system shut-down in accordance with the shut-down procedures in Chapter Four, Daily Operation.
2. Remove 40 Phillips head screws securing the laser cover and remove the cover.
3. Remove the control cable attached to the head board connector (Figure 5-7, item 7).
4. Remove the cable attached to the 15-pin shutter connector (Figure 5-7, item 4).
5. Remove the emission indicator cable (Figure 5-7, item 1).
6. Remove the three screws securing the head board (Figure 5-7, item 3) to the stand-offs.
7. Remove the 4 screws securing the head board to the rear end plate (Figure 4-7, item 8) and remove the head board with the mounting block attached.

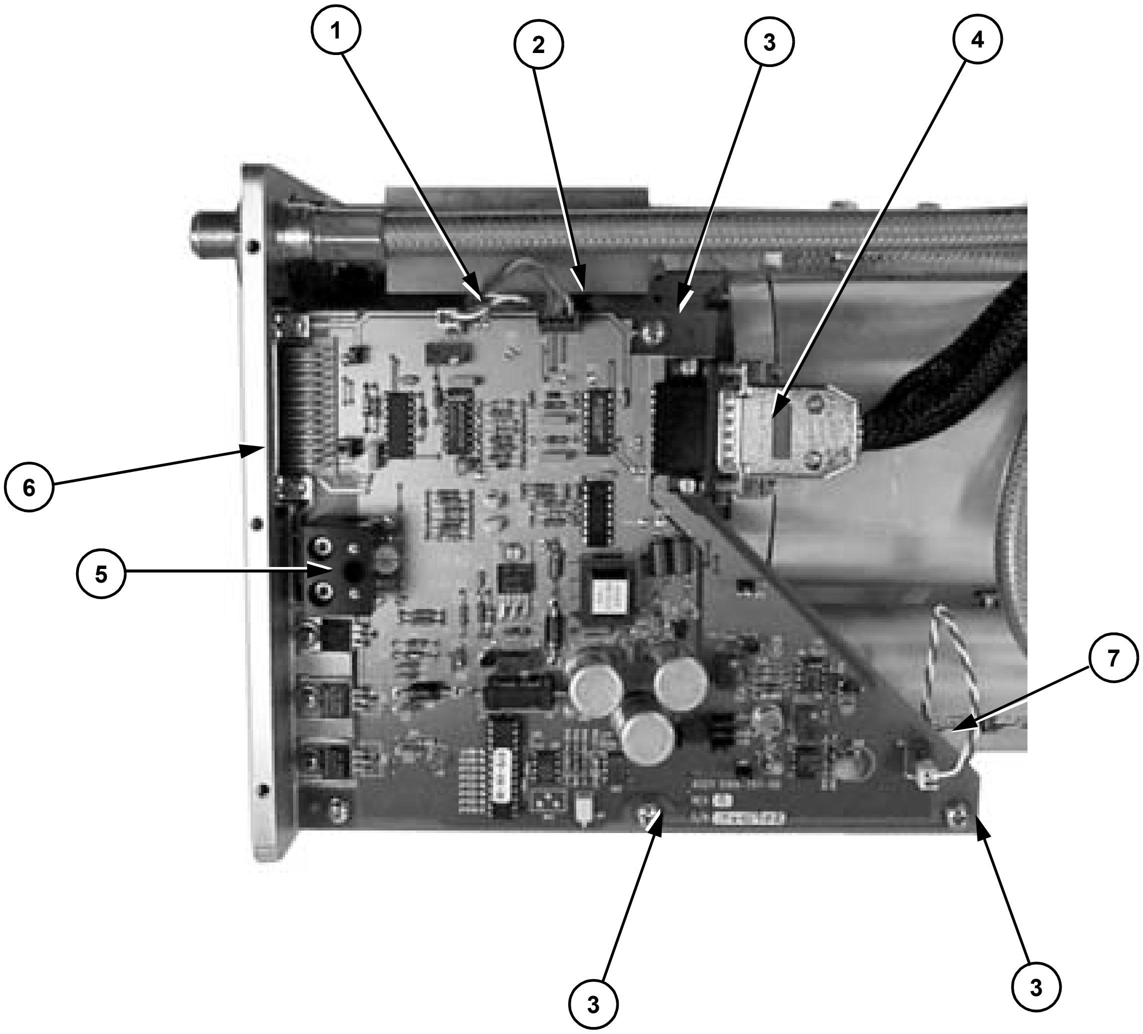
Laser Head Board Installation

Installation is the reverse of removal. Tighten the three head board screws to the stand-offs alternately to avoid distorting the head board. Do not turn on the laser system until the head board has been completely re-installed and the laser head cover is in place. Perform the startup procedures in Chapter Four, Daily Operation.

Water Screen Cleaning

The water screen is located on the laser head inlet water hose connector (Figure 5-2). The water screen should be cleaned when instructed to do so in the troubleshooting procedures. The screen can also be cleaned as part of the user’s periodic maintenance. The frequency of cleaning will be determined by the condition of the facility water source.

1. Perform system shut-down in accordance with the shut- down procedures in Chapter Four, Daily Operation.
2. Use a bucket for water drainage and have a supply of paper towels on hand while disconnecting the water line.
3. Disconnect the laser head inlet water line (Figure 5-2, item 5) from the power module. Disconnect the laser head inlet water line from the laser head by loosening the nut (Figure 5-2, item 6) while preventing the body of the water screen



1. Connector to emission indicator
2. Connector to water flow switch
3. Mounting screws (3). Four additional mounting screws are shown on Figure 4-9.
4. 15 pin connector to shutter
5. Location for installing interlock defeat
6. 25 pin connector
7. Connector to preionizer

Figure 5-7. Laser Head Board

assembly from rotating by holding the second nut with a wrench.

4. Remove and clean the water screen. Inspect the two O-rings to ensure they are free of damage. Replace if necessary. Spare O-rings are located in the maintenance kit.
5. Installation is the reverse of removal. Use Teflon pipe tape when re-installing the water lines. Verify that there are no water leaks as follows:
    - Open the water drain.

- Slowly open the water supply.
- With the water supply pressure and water line differential pressure in accordance with Table 3-1, check all connections for leaks.

6. Perform the startup procedures in Chapter Four, Daily Operation.

OPERATOR'S MANUAL

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CHAPTER SIX
K-300 BASIC PLUS SYSTEM

COHERENT

Description

The Diamond laser is a modular, RF excited, sealed-off industrial CO_2 pulsed laser. The Diamond K-300 Basic Plus system (Figure 6-1) consists of a laser head, RF amplifier, Diamond Digital Interface (DDI), and an RF cable. A DC power supply is required and is supplied by Coherent. The Diamond K-300 has a 80 cm resonator with a 20 to 300 Watt average output power range, respectively. Specifications are listed in Chapter One of this manual.

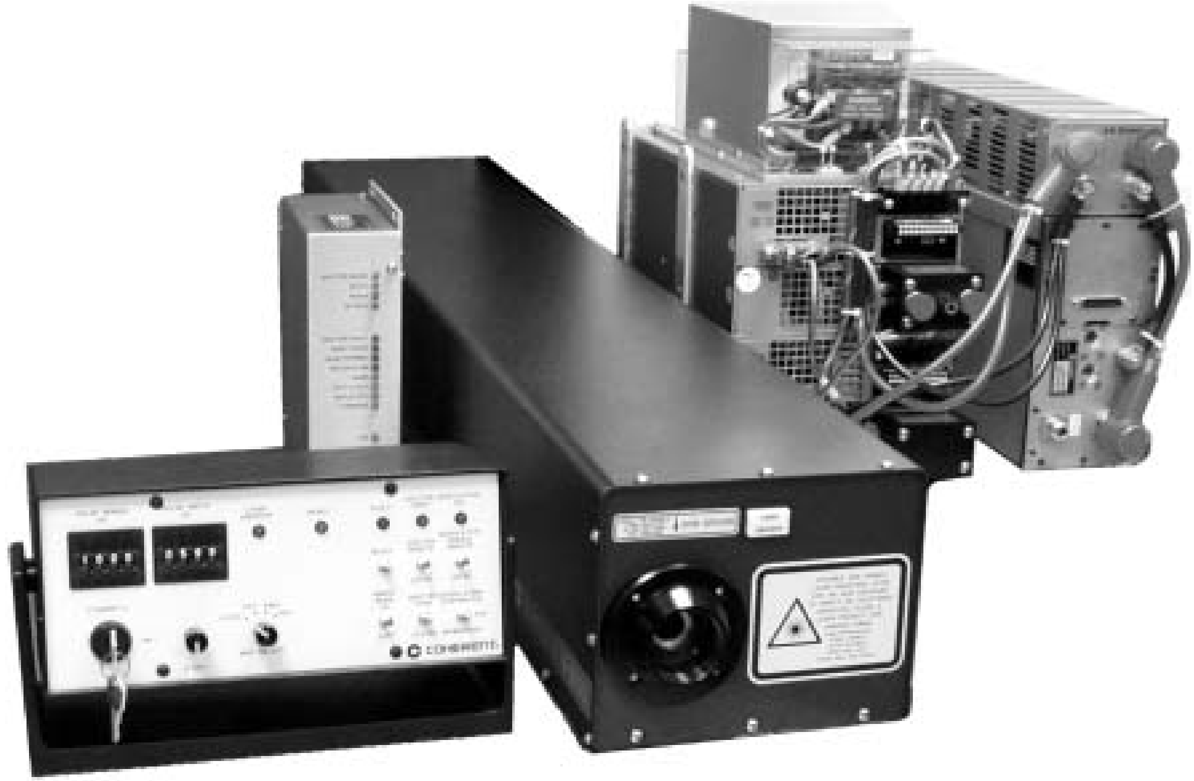


Figure 6-1. Diamond K-300 Basic Plus Laser System

The Diamond can operate in many pulse formats which allows user control of the output beam and power output depending on the user supplied control system. A simplified laser system block diagram is shown on Figure 6-2.

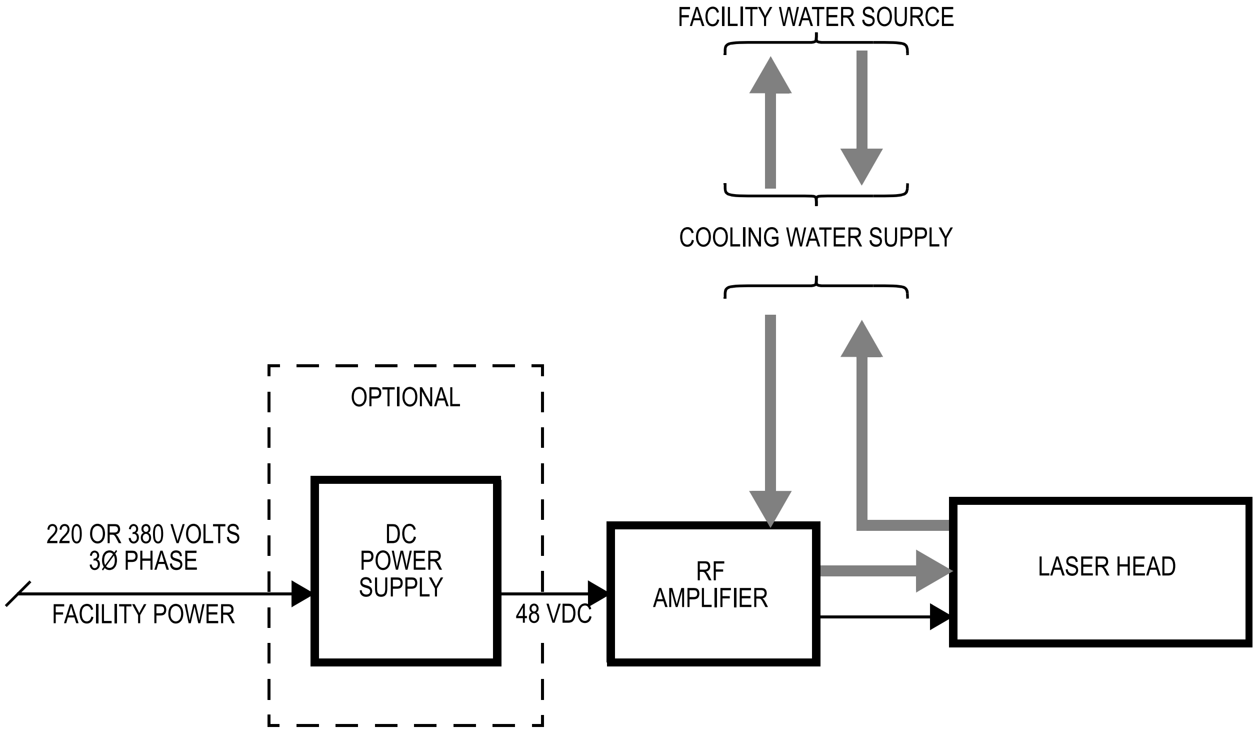


Figure 6-2. Simplified System Block Diagram

Purpose of This Chapter

This chapter is designed to describe the unique features of the K-300 Basic Plus configuration as compared to the K-300 Performance Package version. Additional information about installation and operations of the RF amplifier, Diamond Digital Interface (DDI), and DC power supply are included in this chapter.

System Installation

Installation consists of:

- Preparing the facility for installation
- Performing a receiving inspection
- Unpacking and inspecting system components
- Mounting the laser system components
- Checking the input voltage range of the DC power supply
- Interconnecting the electrical cables
- Connecting the water lines to the water source and drain
- Turning on the laser system

Table 6-1. Equipment Required for Installation (Not Furnished With System)

EQUIPMENT	QUANTITY	USE
Electrical connector (DC power supply)	1	Connector mates with facility power outlet. The connector attaches to the input power cable on the DC power supply and must be capable of handling the input voltage and current requirements stated in Table 1-3.
Mounting bolts	4	The mounting bolts secure the laser head. • 0.375-16 UNC-2B (inches, domestic) • M10 x 1.5 (metric)
Optics nitrogen purge	As required	1/4 inch (6.3) O.D. Teflon, polyethylene or polypropylene tubing for Nitrogen purge gas.
Mounting screws	12	The mounting screws secure the RF amplifier, DDI, and DC power supply. • 10-32 UNC-2B (inches, domestic) • M6 (metric)

Preparing the Facility for Installation

Ensure facility electrical, water, and nitrogen (optional) are adequate for laser operation.

The facility outlet for the DC power supply must have a fuse or circuit breaker on each phase at 208 VAC or 380 VAC. Consult the appropriate local electrical code to determine the required current rating for the fuses or circuit breakers.

Refer to the paragraph titled Electrical Service, and to Table 1-3 for electrical requirements. Refer to the paragraph titled Cooling Water, and to Table 3-1 and Table 3-2 for water requirements.

Refer to the paragraph titled Nitrogen Optics Purge, and to Table 1-3 for nitrogen requirements.

Receiving Inspection

Before unpacking the Diamond K-300, inspect all shipping containers and note any damage. Any indication of damage should be noted on the bill of lading. The shipping carrier is responsible for damage in transit. Immediately report damage to the shipping carrier and to Coherent.

Unpacking

To avoid equipment damage, exercise care when removing wrapping materials.

To minimize the risk of functional or cosmetic damage, unpack the laser system at the installation site. While unpacking the Diamond laser, verify that all items on the packing list have been received. Save all containers and packing material including the water line end caps. They will be required if it becomes necessary to re-ship the equipment.

Mounting Laser System Components

The laser head, RF amplifier, DDI unit, and DC power supply have provisions for permanent mounting. Refer to the figures listed below for overall dimensions, location of the mounting holes and depth of mounting bolts.

- Laser head, Figure 6-3
- RF amplifier, Figure 6-4
- DDI unit, Figure 6-5
- DC power supply, Figure 6-6

Refer to Figure 6-7, Mounting Distances, prior to mounting the laser components in order to take into consideration cable lengths.

Also note the precision beam alignment slots (Figure 6-3) on the bottom of the laser head which serve as a reference for output beam alignment. The slots make it possible to quickly interchange a replacement laser head with a minimum of optics alignment to the user beam delivery system.

The lifting and carrying of the laser head should be done by two people. The laser head should be held by the base. Once at it final location, it should be anchored using the mounting holes provided in the base.

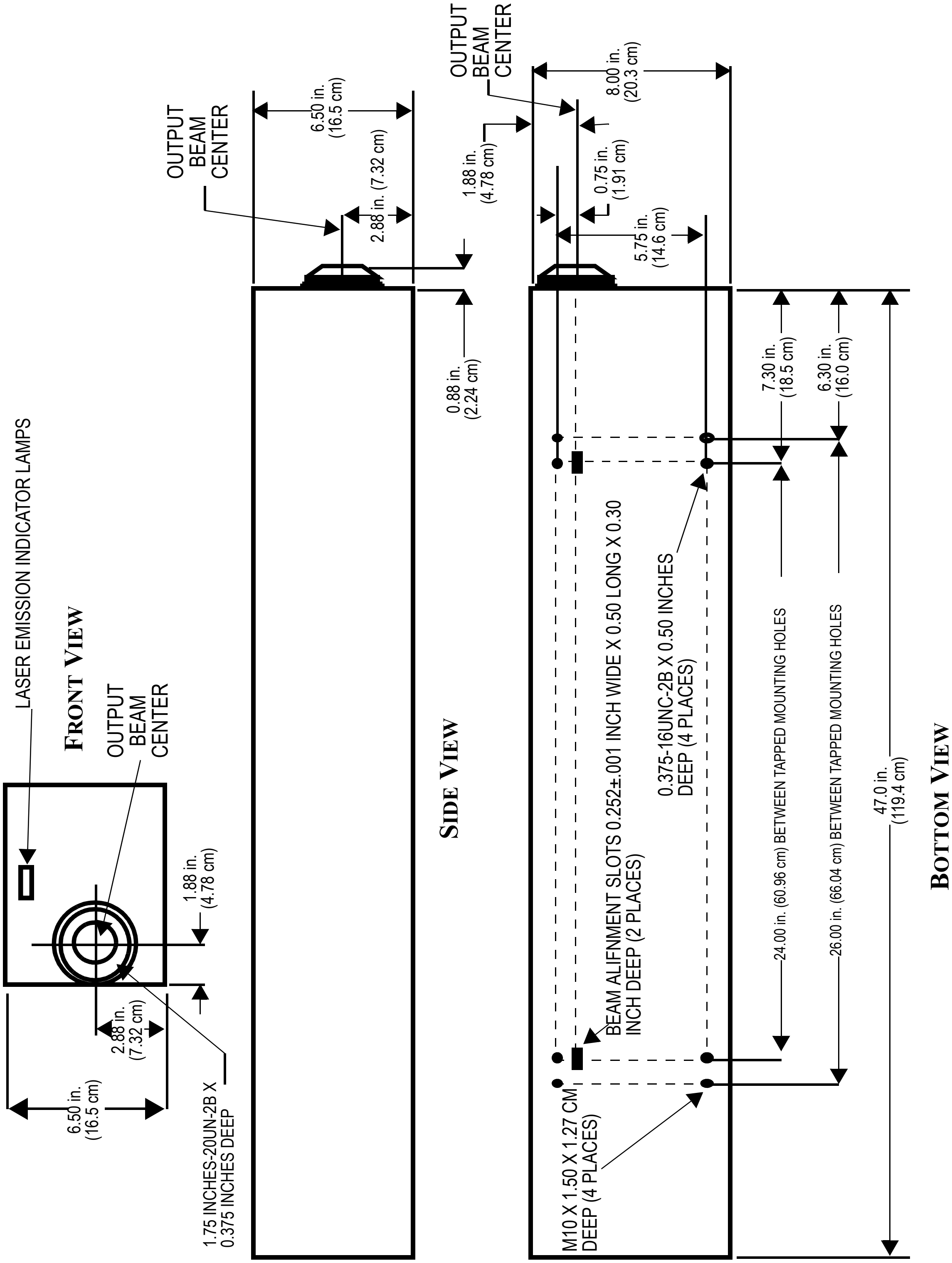
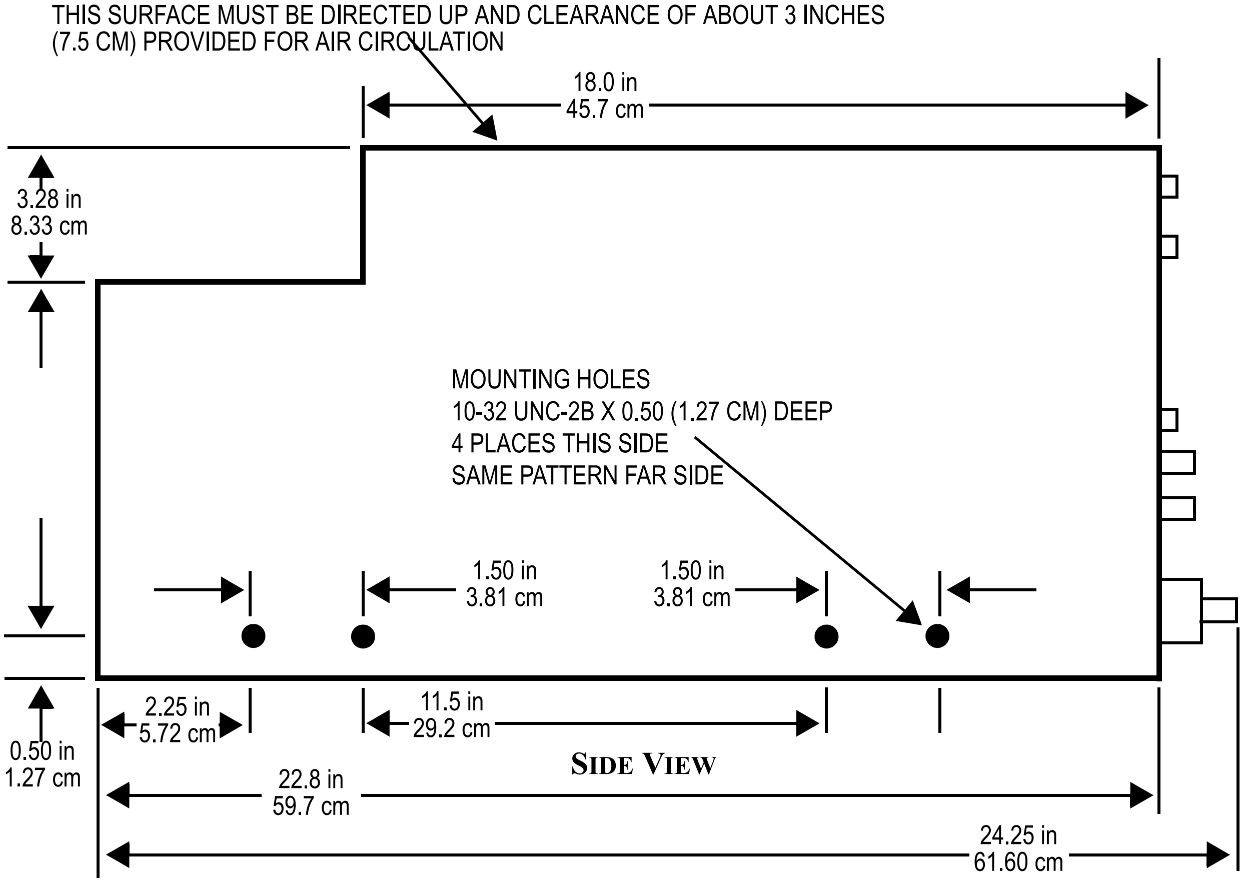
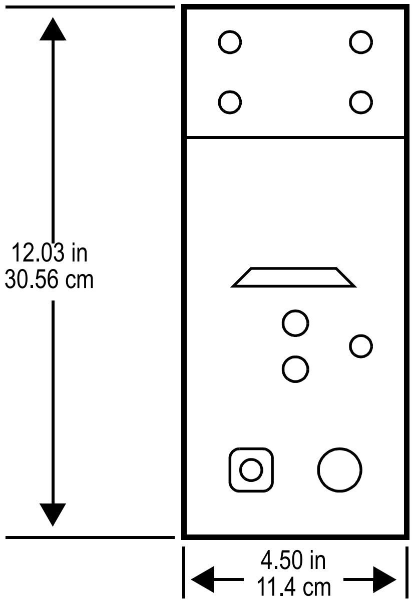

LASER EMISSION INDICATOR LAMPS
FRONT VIEW
OUTPUT BEAM CENTER
1.88 in. (4.78 cm)
2.88 in. (7.32 cm)
6.50 in. (16.5 cm)
1.75 INCHES-20UN-2B X 0.375 INCHES DEEP
OUTPUT BEAM CENTER
6.50 in. (16.5 cm)
2.88 in. (7.32 cm)
0.88 in. (2.24 cm)
SIDE VIEW
OUTPUT BEAM CENTER
8.00 in. (20.3 cm)
1.88 in. (4.78 cm)
0.75 in. (1.91 cm)
5.75 in. (14.6 cm)
BEAM ALIFNMENT SLOTS 0.252±.001 INCH WIDE X 0.50 LONG X 0.30 INCH DEEP (2 PLACES)
0.375-16UNC-2B X 0.50 INCHES DEEP (4 PLACES)
M10 X 1.50 X 1.27 CM DEEP (4 PLACES)
7.30 in. (18.5 cm)
6.30 in. (16.0 cm)
24.00 in. (60.96 cm) BETWEEN TAPPED MOUNTING HOLES
26.00 in. (66.04 cm) BETWEEN TAPPED MOUNTING HOLES
47.0 in. (119.4 cm)
BOTTOM VIEW

Figure 6-3. Laser Head Dimensions and Mounting Hardware Locations

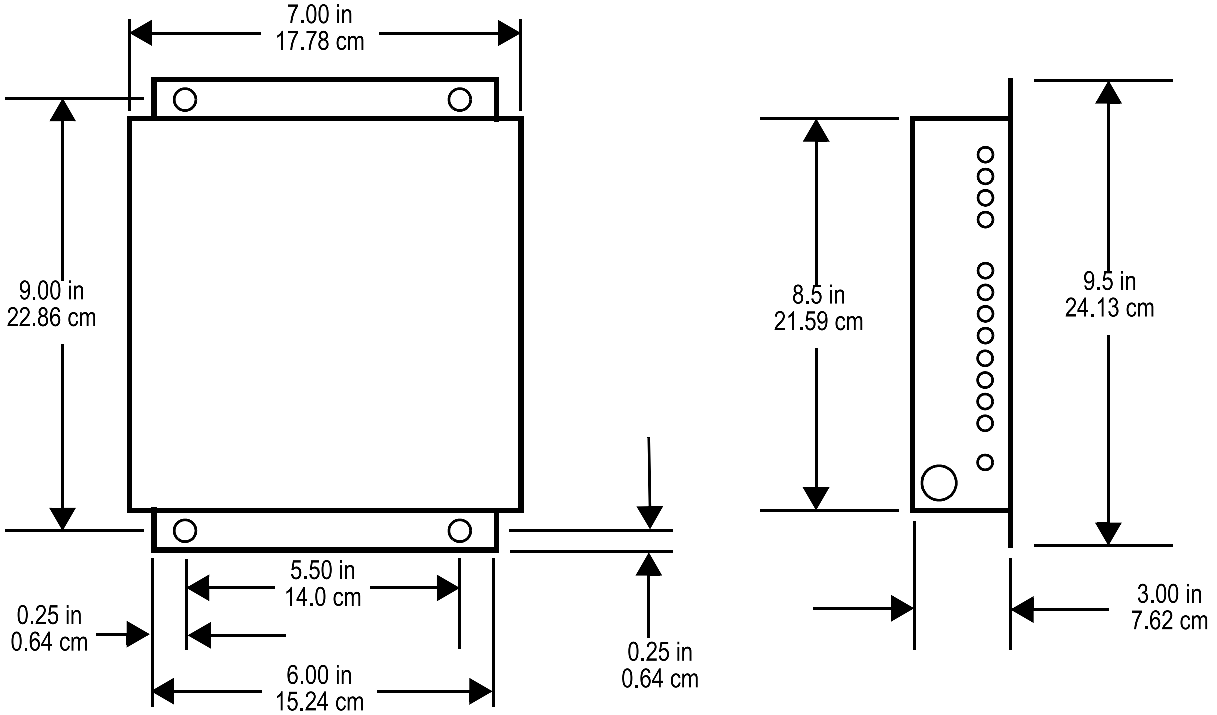


SIDE VIEW



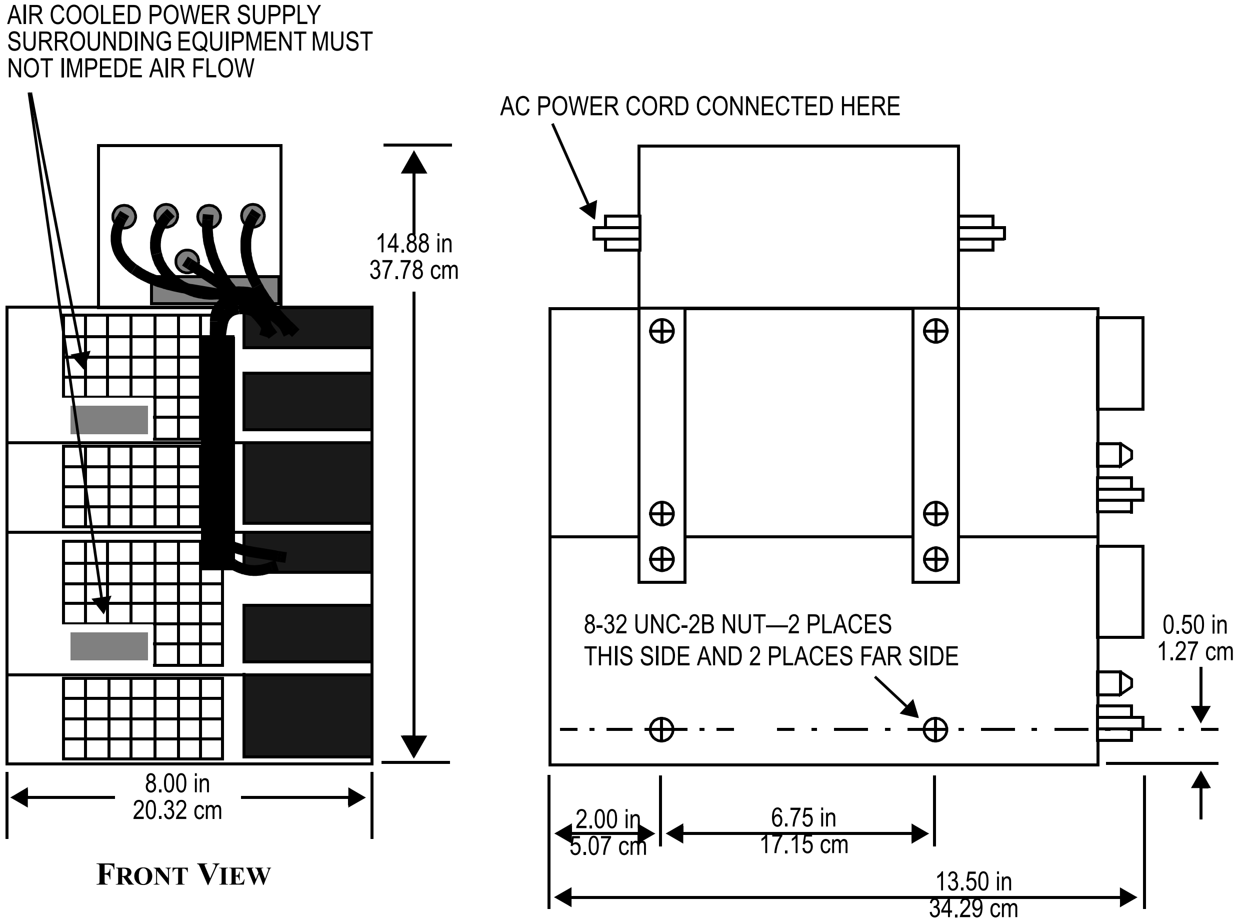
FRONT VIEW

Figure 6-4. RF Amplifier Dimensions and Mounting Hardware Locations



Top View **Front View**

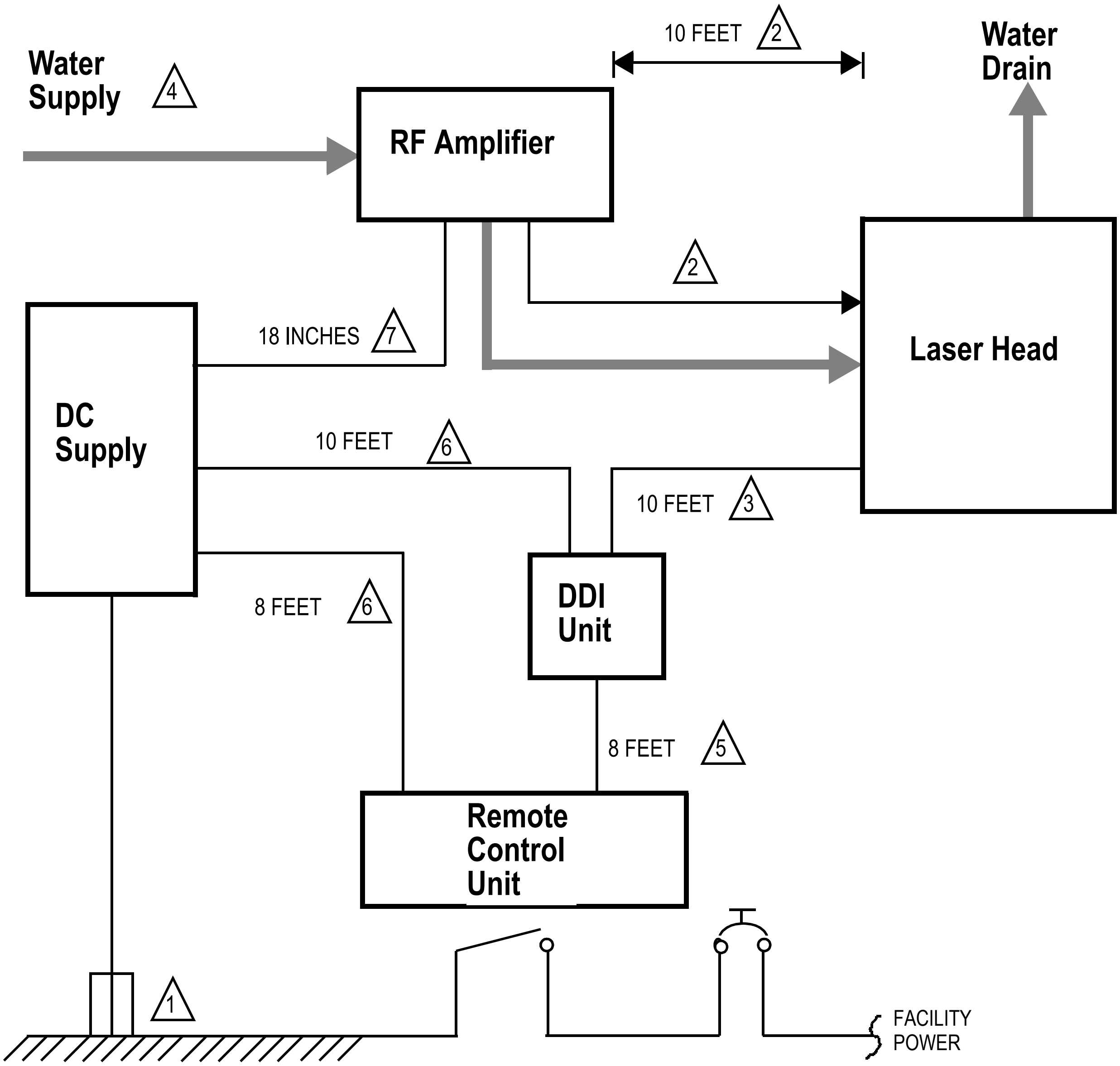
Figure 6-5. Diamond Digital Interface Unit Dimensions and Mounting Hole Locations



FRONT VIEW

SIDE VIEW

Figure 6-6. DC Power Supply Option Dimensions and Mounting Hardware Locations



1 User supplied wiring

2 The RF cable is available in additional increments to retain RF matching. No splicing or connectors are permitted.

3 This is a standard 10 foot cable with DB25 connectors and can be extended up to 100 feet with optional cables. Note that RF cabling and cooling water lines will be the same length.

4 Water lines can be any length as long as the pressure requirements listed in Table 3-1 are met.

5 This is a standard 8 foot cable with DB37 connectors. it can be extended up to 100 feet.

6 This is a standard 10 foot cable length with 4-pin connectors on both ends.

7 Maximum length is 18 inches. Cables are provided with DC Power Supply.

Figure 6-7. Mounting Distances Diagram

Input Power Connection to DC Power Supplies

This section covers selecting the input voltage to the DC power supplies. The input voltage to this supply can be selected from two different voltage ranges. The lower range is 208 ±10% VAC and the upper range is 380 ±10% VAC. The input power cable to the DC power supplies is connected to line filters and then to two 2.5 kW DC power supplies that are operating in parallel. These units are turned on through a 25 pin cable that connects to the DDI unit.

Ensure that the correct input voltage has been selected on both DC power supplies before applying input power to this unit. Failure to have the proper input voltage will damage the supplies.

Verify that the proper input voltage has been selected for the DC power supplies. The input voltage is indicated in the windows immediately adjacent to the input power connections (Figure 6-9). Since there are two DC power supplies operating in parallel, the correct input voltage must be selected for both power supplies.

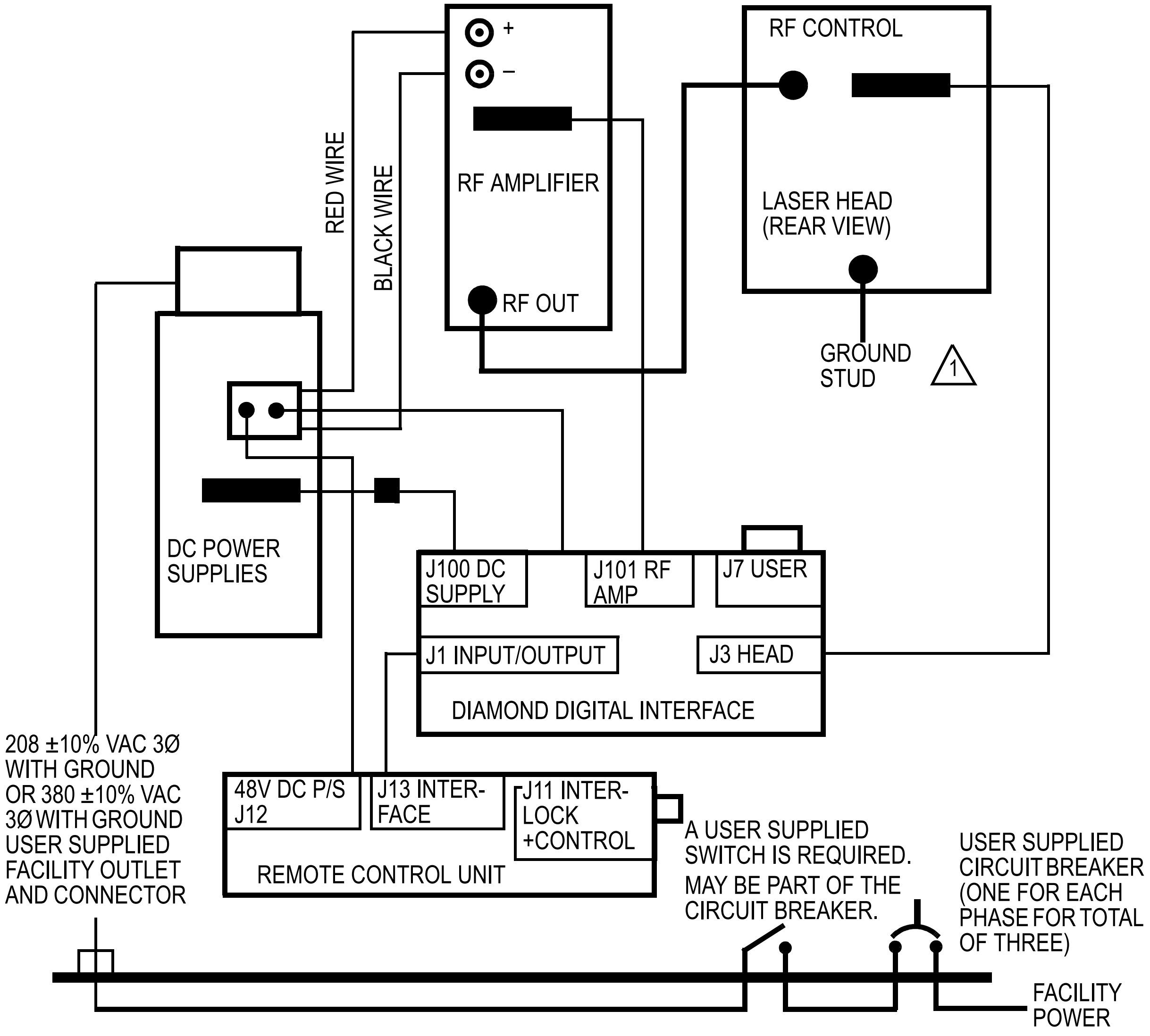
If the correct voltage is not indicated in both these windows, see the next section for selecting the desired input voltage range. This step must be taken before any power is applied to the DC power supplies.

Refer to Table 3-3 and Figure 6-8, Laser System Interconnecting Diagram, for the recommended facility power system. The unit is designed to have a switched fuse box or switchable circuit breaker located close to the unit or the operator. The fuse box or circuit breaker shall be marked as the disconnecting device. Each phase must have a fuse or circuit breaker. See Table 3-3 for wire size. Do not connect the DC power supplies to the facility power until all connections have been completed.

Install the user supplied connector on the DC supply power cable by connecting the green wire to the ground terminal that will mate to the facility ground. Connect the red, white, and black wires to the connector terminals that will mate to each of the three facility phases. All wires are #12 gauge.

Ensure that the proper size of fuse or circuit breaker is installed on each of the facility power line that the laser will be connected. Ensure that the circuit breaker is set to off.

Do not connect the facility power until the remaining electrical connections have been made.



[1] CONNECT GROUND STUD TO PROTECTIVE EARTH GROUND. USE 12 AWG WIRE SIZE (MINIMUM). MAXIMUM LENGTH 60 INCHES (1.5 METERS). REFERENCE FIGURE 4-8 AND TABLE 4-5 ITEM 6.

Figure 6-8. Laser System Interconnection Diagram

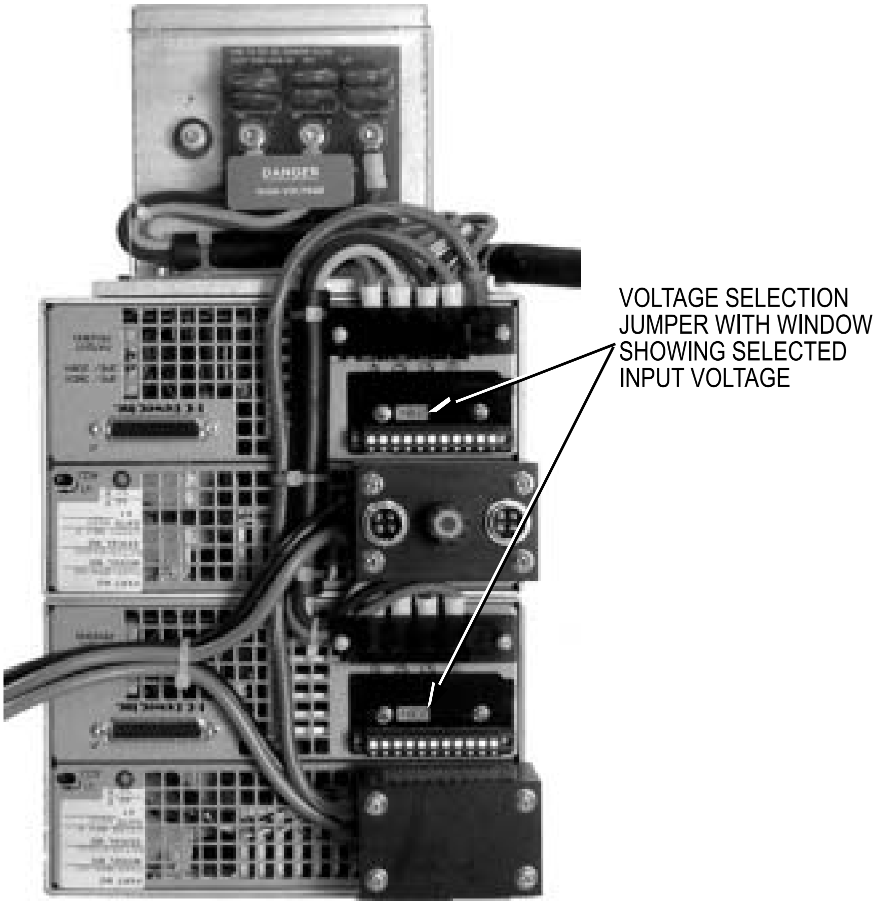

VOLTAGE SELECTION JUMPER WITH WINDOW SHOWING SELECTED INPUT VOLTAGE
DANGER

Figure 6-9. DC Power Supply

Changing Input Voltage to DC Power Supply

This section describes the method to change the input voltage range of the DC power supplies. This operation should be completed by a properly trained technician.

Ensure that the supplies are not connected to the input power. Failure to do so is a safety hazard and also will damage the DC supplies.

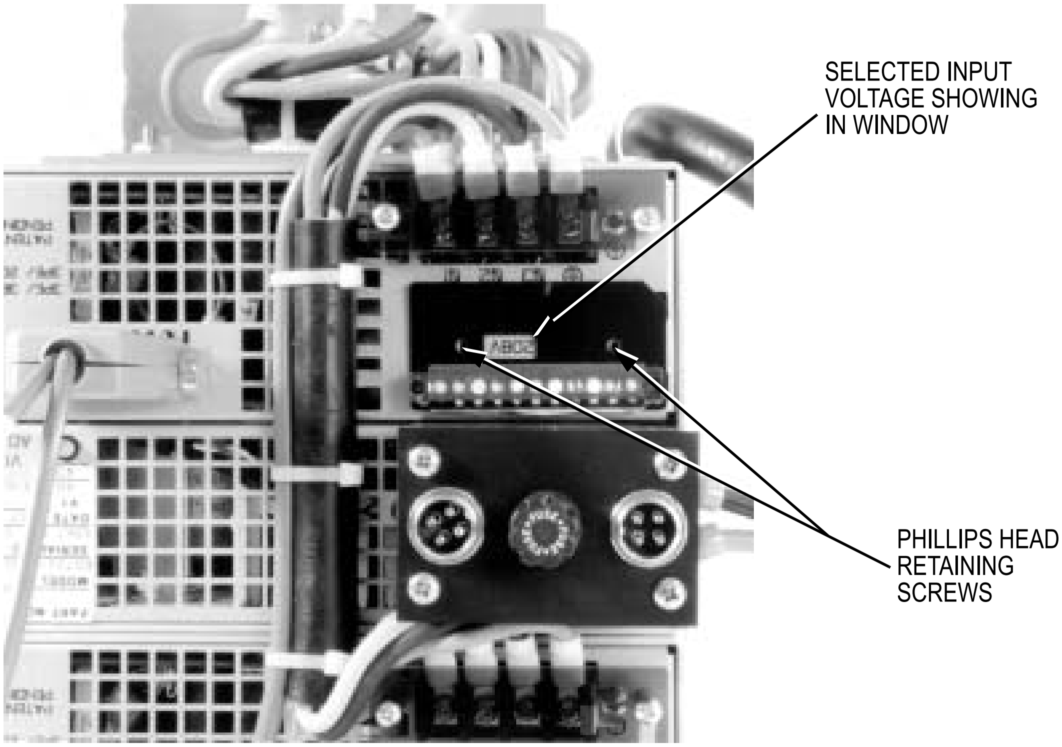
Refer to Figure 6-9 for the location of the voltage select jumper on the DC power supplies. Figure 6-10 shows the jumper in the two different positions for the two input voltage ranges.

1. Disconnect both DC power supplies from the input facility power supplies.
2. Remove the two Phillips head screws from the voltage selector jumper shown in Figure 6-10. Do this same operation for the second DC power supply.
3. Remove the voltage selector jumper and rotate 1/2 turn (180°) and re-install the jumper. The correct voltage should now show in the window through on the jumper.
4. Do this same operation of step 3 for the second DC power supply.
5. Verify that the correct voltage is showing through the window on the jumper on both power supplies. Replace the two Phillips head screws in both jumpers.

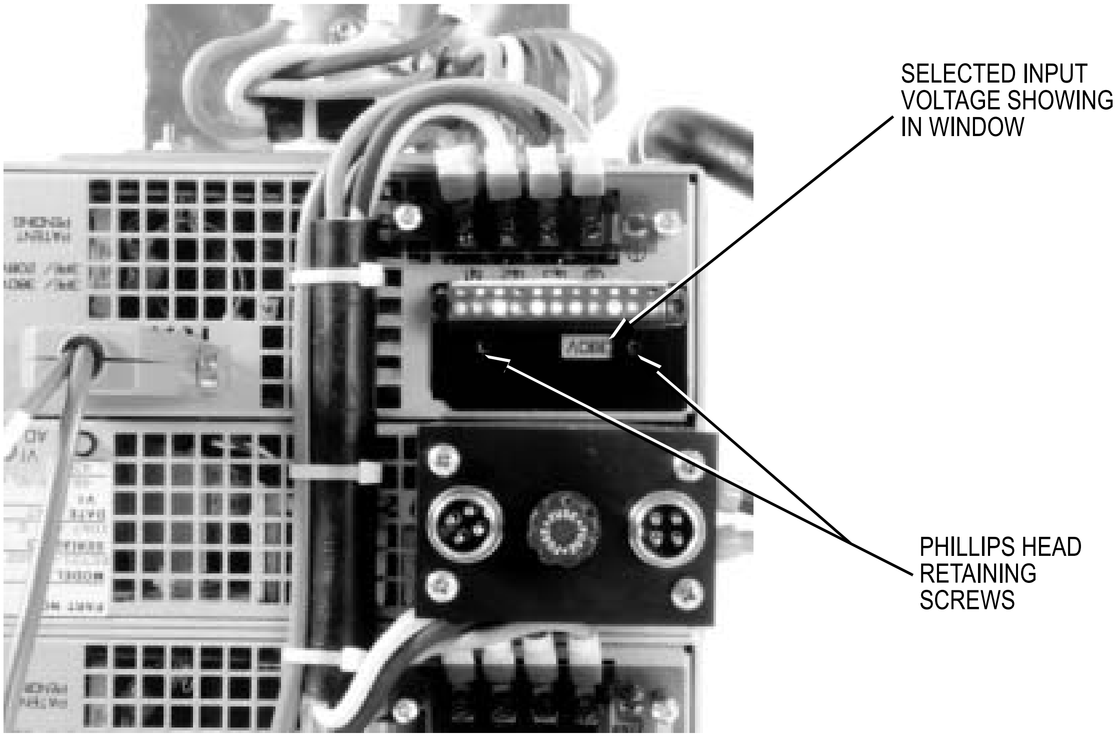
Do not connect the DC power supply to facility power until all laser system electrical interconnections are completed. Ensure that the facility power is turned off.

Interconnecting Electrical Cables

Refer to Figure 6-8, Laser System Interconnection Diagram and connect the electrical cables as follows.



A. 208 VAC INPUT VOLTAGE SELECTED



B. 380 VAC INPUT VOLTAGE SELECTED

Figure 6-10. Voltage Selection Jumper Showing Selected Input Voltage

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⚠

Ensure that all electrical connections are made according to the following paragraphs before the facility power is applied to the unit. Failure to do so can put expose operators to hazardous voltages.

---

1. Connect the red wire (+48 VDC) from the DC power supply to the lug labeled +48 V on the RF amplifier.
2. Connect the black wire from the DC power supply to the lug labeled 48 V RETURN on the RF amplifier.
3. Connect the coaxial RF cable at the N connector on the RF amplifier labeled RF OUT. The other end of this cable should be connected to the N connector on the laser head labeled RF. Ensure that both ends of this cable are tightened securely.

⚠

Use only the coaxial RF cable provided with this unit. No splicing or connectors are permitted. See the paragraph titled RF Cable Installation and Option in Section Three for installation of the RF cable and options for other cable lengths.

---

4. Connect one of the 25 pin cables to the 25 pin connector on the RF amplifier. The other end of this cable connects to the rear panel of the DDI at the connector labeled J101 RF AMP.
5. On the laser head, connect a 25 pin cable at the connector labeled CONTROL. The second connector on this cable assembly is attached to the J3 HEAD connector on the DDI.
6. Another 25 pin cable is connected to the DDI unit at the label J100 DC SUPPLY. This cable connects to the 25 pin cable assembly of the DC power supply.
7. Connect a 4 pin cable assembly between one of the 4 pin connectors on the DC power supply and the +48 V IN connector on the DDI.
8. A second 4 pin cable assembly is connected to the remaining 4 pin connector on the DC power supply and the other end to a 4 pin connector on the rear panel of the remote control unit labeled 48 VDC/PS.
9. The final cable to attach is a 37 pin cable. One end is connected to the remote control unit at the connector labeled INTERFACE and the other end to the connector labeled J1 INPUT/OUTPUT on the DDI unit.

Water Line Connections

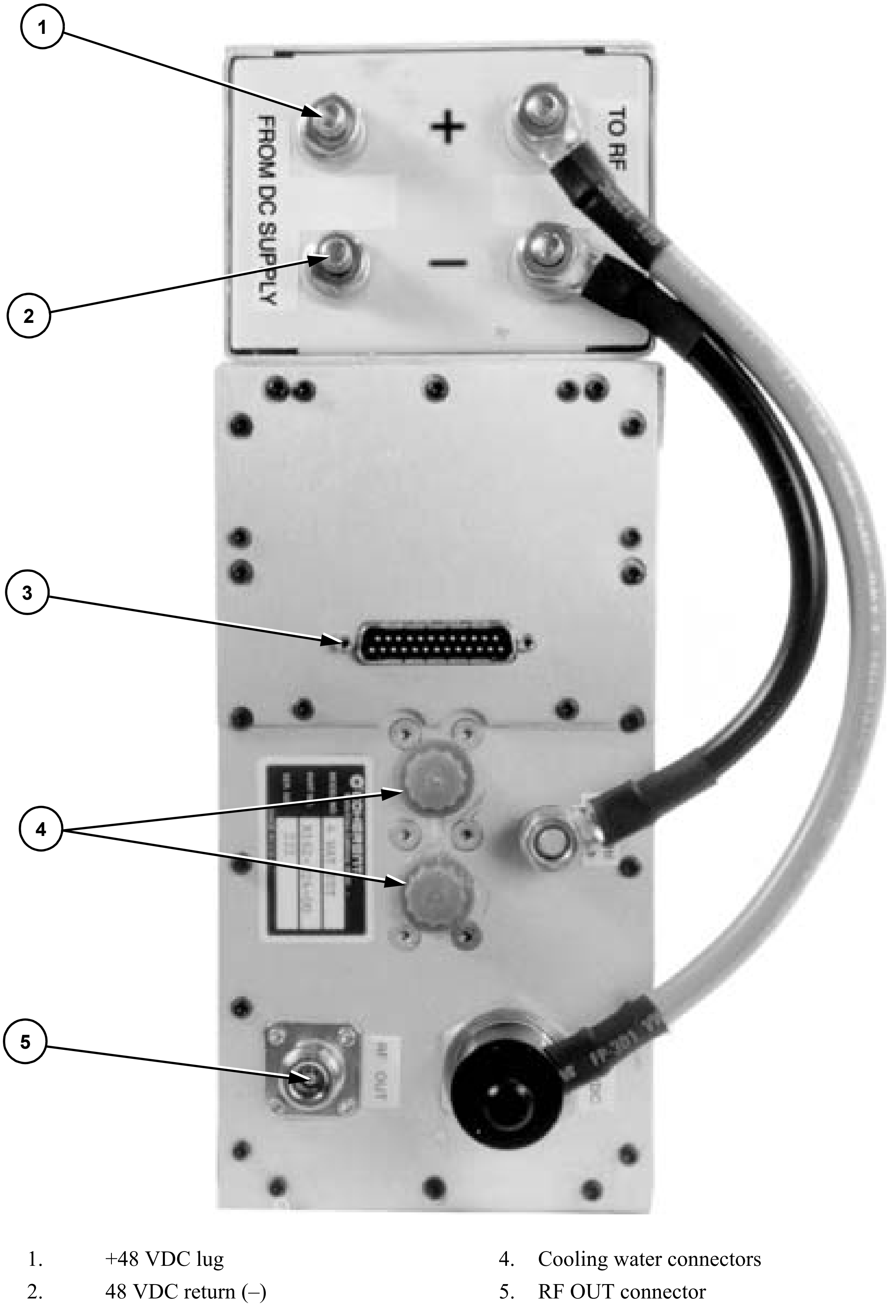
Refer to Figure 6-7 for the interconnection diagram. Refer to Figure 4-8 and Figure 6-11 for the location of laser head and RF amplifier water hose connectors.

The cooling water source can be facility water or a closed-loop cooling system. If facility water is used, ensure that the water meets the requirements listed in Table 1-3. Refer to in the paragraph titled Cooling Water (located in this chapter) for additional information.

1. Connect the 3/8" ID nylon reinforced PVC water hose from the water source to the RF amplifier. Fittings are provided for use of a hose without attached fittings. Use the teflon tape as a thread seal for these fittings.
2. Connect a nylon reinforced PVC water hose from the laser head water hose connector labeled WATER OUT to the facility water drain. Use the hose barb fittings provided.
3. Connect a nylon reinforced PVC water hose from the RF amplifier to the water connector on the laser head labeled WATER IN. Use the hose barb fittings provided.
4. Verify that there are no water leaks as follows:
    - Open the valve in the water drain line.
    - Slowly open the valve in the water supply line.
    - With the water supply pressure and water line differential pressure in accordance with Table 1-3, check all connections for leaks.

Controls and Indicators

This section covers the items that are specific to the K-300 Basic Plus system. The laser head and the remote control unit are identical for both the K-300 versions covered in this manual. See Chapter 4 of this manual for description of the operation and controls laser head and remote control unit. The following section covers the controls and indications of the RF power supply, the DDI, and the DC power supply option.



1. +48 VDC lug
2. 48 VDC return (–)
3. Control cable connector
4. Cooling water connectors
5. RF OUT connector

Figure 6-11. RF Amplifier Interface Connectors

Table 6-2. RF Amplifier Interface Connectors

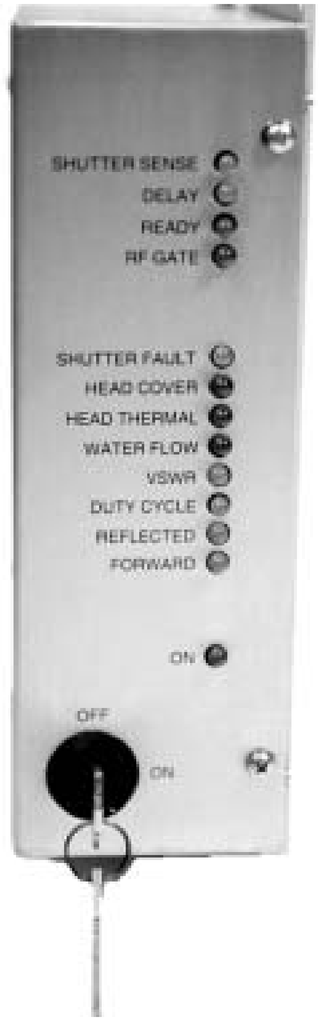
ITEM	CONTROL	FUNCTION
1	From +DC Supply	Connects +48 VDC from the DC power supply to the RF amplifier. Refer to Figure 6-8 for the laser system interconnection diagram.
2	From –DC Supply	Connects the RF amplifier return to the DC power supply. Refer to Figure 6-8 for the laser system interconnection diagram.
3	Control cable connector	Connector for a DB25 interconnection cable. This connector supplies control and input modulation signals to the RF amplifier and supplies status information from the RF amplifier. Refer to Chapter Four for a complete description of signals at this connector.
4	Cooling water connector	Connector for the 3/8" I.D. nylon reinforced PVC cooling water hose. Cooling water travels from the RF amplifier to the laser head. Either connector can be used for inlet or outlet. Refer to Figure 6-8 for the laser system interconnection diagram. Refer to Chapter Three for additional information on cooling water and closed loop cooling systems.
5	RF OUT connector	Connector for interconnection cable that supplies RF from the RF amplifier to the tube through the supplied RF interconnection cable. Refer to Figure 6-8 for the laser system interconnection diagram.

External Safety Interlock

The Diamond system is shipped with a plug installed on the J7 USER connector on the DDI unit. A safety interlock circuit can be wired to this connector and it will automatically turn the laser off when activated. If this unit is being used with a remote control, then connect pin 4 and pin 8 into the system interlock. When an open circuit is provided across these pins laser operation is not allowed and a closed circuit allows operation. The interlock from the Diamond system operates at 5 VDC which is supplied from the DC power supply whenever the AC power is applied to this unit. For this interlock to function completely, pin 3 must be connected to pin 6 as well as pin 5 connected to pin 9.

When the Diamond K-300 Basic laser system is being used without the remote control unit, then connect pins 8 and 9 into the system interlock. Again an open circuit will prohibit laser operation and a close circuit will allow laser operation.

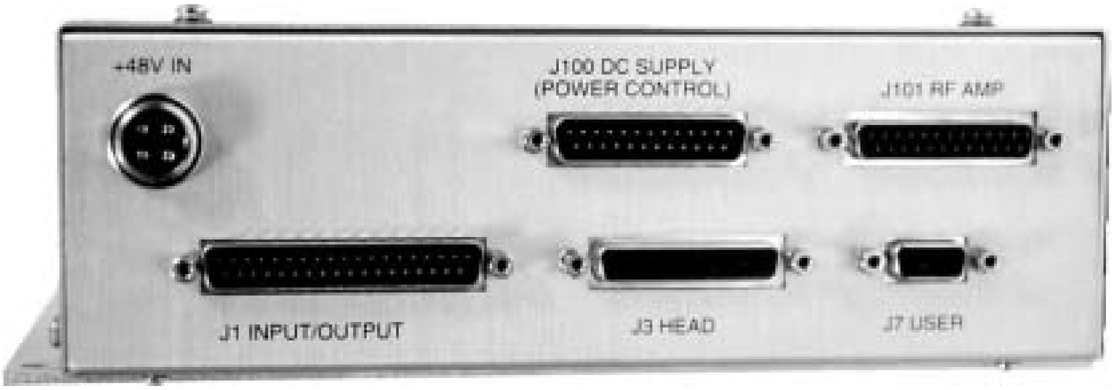
Similar functions are also found on the connector labeled INTERLOCK & CONTROL on the rear panel of the remote control unit. In this case an open circuit across pins 14 and 15 will prohibit laser operation and a closed circuit will allow laser operation. This circuit also operates at 5 VDC.



FRONT VIEW

1. SHUTTER SENSE indicator
2. DELAY indicator
3. READY indicator
4. RF GATE indicator
5. SHUTTER FAULT indicator
6. HEAD COVER indicator
7. HEAD THERMAL indicator
8. WATER FLOW indicator
9. VSWR indicator
10. DUTY CYCLE indicator
11. REFLECTED indicator
12. FORWARD indicator
13. PWR ON indicator
14. Keyswitch

Figure 6-12. Diamond Digital Interface Unit Controls, Indicators, and Connectors



REAR VIEW

15.	48V IN 4-pin connector	18.	J1 INPUT/OUTPUT connector
16.	J100 DC SUPPLY connector	19.	J3 HEAD connector
17.	J101 RF AMP connector	20.	J7 USER connector

Figure 6-12. Diamond Digital Interface Unit Controls, Indicators, and Connectors (Continued)

Table 6-3. Diamond Digital Interface Unit Controls, Indicators, and Connectors

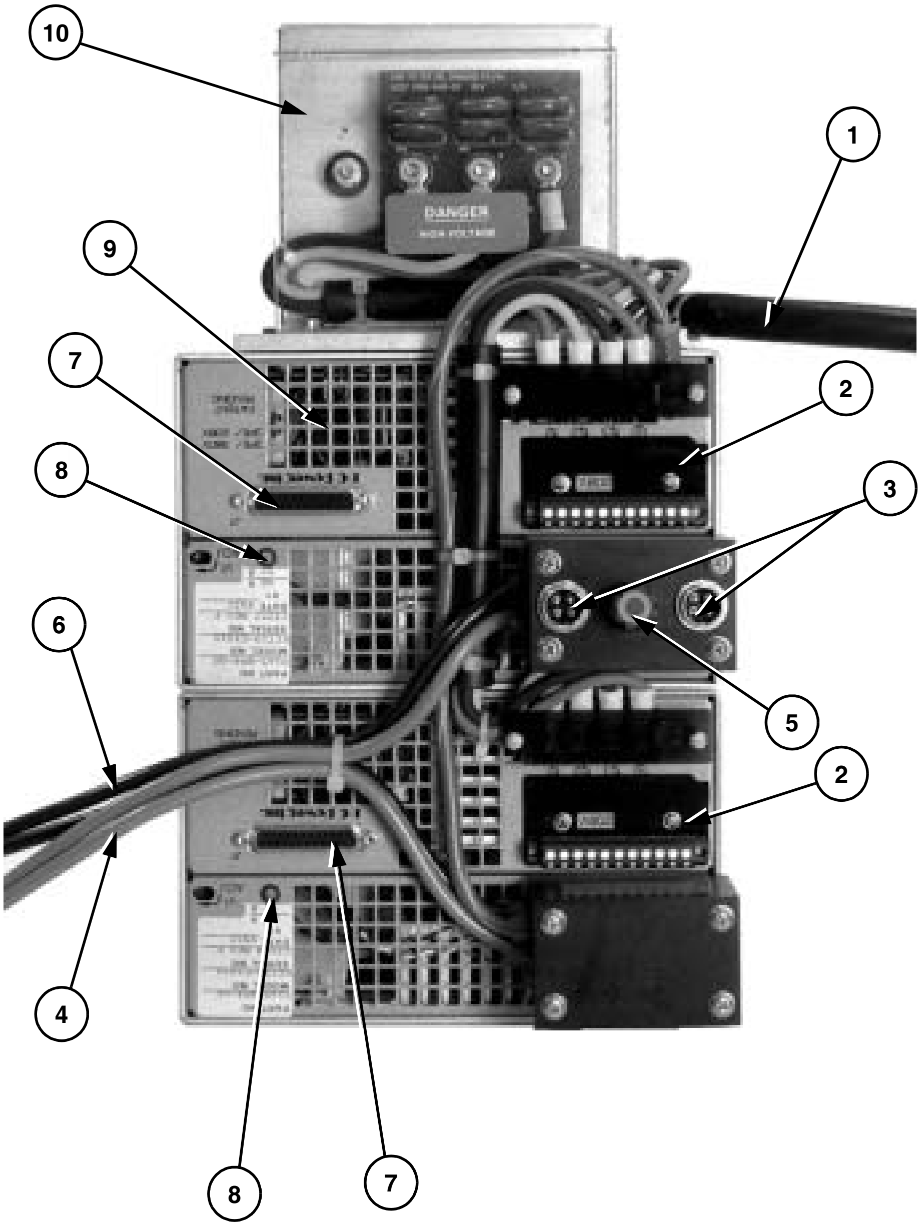
INDEX	CONTROL	FUNCTION
1.	SHUTTER OPEN indicator	Amber indicator turns on when the shutter is open. Active in both SHUTTER REMOTE/LOCAL switch positions. Flashes when there is a shutter fault.
2.	DELAY indicator	Amber indicator flashes on and off when the system delay of approximately 10 seconds is in process. The delay occurs at system startup from a cold start and after clearing a fault. This indicator turns off when the delay is complete.
3.	READY indicator	Green indicator turns on when the system is ready for operation and there are no faults.
4.	RF GATE indicator	Green indicator turns on when there are no interlock or fault problems.
5.	SHUTTER FAULT indicator	Red indicator turns on indicating the shutter is not in the commanded position. When shutter fault active laser operation is not possible.

Table 6-3. Diamond Digital Interface Unit Controls, Indicators, and Connectors (Continued)

INDEX	CONTROL	FUNCTION
6.	HEAD COVER indicator	Red indicator turns on typically indicating that the head cover is not securely attached. If the laser head cover has been removed for maintenance, an interlock defeat must be installed. The system will be held in an off condition, not start, or restart when this indicator is on. Refer to the Table 5-1 for information on troubleshooting and clearing this condition.
7.	HEAD THERMAL indicator	Red indicator turns on indicating excessive heat buildup on the shutter assembly beam dump which dissipates heat when the shutter is closed. The Diamond can continue to lase when the shutter is closed and modulation is turned on. This is usually caused by insufficient water flow to the shutter. The system will be held in an off condition, not start, or restart when this indicator is on. Refer to the Table 5-1 for information on troubleshooting and clearing this condition.
8.	WATER FLOW indicator	Red indicator turns on indicating that the water flow is too low or is flowing in the wrong direction. The system will be held in an off condition, not start, or restart when this indicator is on. Refer to the Table 5-1 for information on troubleshooting and clearing this condition.
9.	VSWR indicator	Amber indicator turns on indicating that the ratio of the RF reflected voltage to the RF forward voltage exceeds the factory set VSWR limit. The indicator can be reset by toggling the RESET switch. If the problem continues, this could indicate a problem with the laser tube or RF cable. Refer to the Table 5-1.
10.	DUTY CYCLE indicator	Amber indicator turns on indicating either the duty cycle exceeds 60% or the pulse width exceeds 999 µsec. Duty cycle is the ratio of the pulse width to the pulse period multiplied by 100%. Refer to Figure 4-4 for operating parameters limits. The indicator can be reset by toggling the RESET switch on the remote control unit.
11.	REFLECTED indicator	Amber indicator turns on indicating that the reflected RF power from the laser tube (monitored by the RF amplifier located in the power module) is greater than a factory set level. Indicator is illuminated only when fault exists. The indicator on continuously indicates a potential problem with the tube. The indicator can be reset by toggling the RESET switch. Refer to the Table 5-1.
12.	FORWARD indicator	Amber indicator turns on indicating that the forward RF power from the RF amplifier to the laser head is lower than a factory set level indicator is illuminated only when fault exists. If indicator is on continuously, this could indicate a problem with the RF power supply. The indicator can be reset by toggling the RESET switch. Refer to the Table 5-1.

Table 6-3. Diamond Digital Interface Unit Controls, Indicators, and Connectors (Continued)

INDEX	CONTROL	FUNCTION
13.	PWR ON indicator	Green indicator turns on indicating that +48 V power is applied to the DDI. The keyswitch on both the remote control unit and on the DDI must be turned on before this indicator will light.
14.	Keyswitch	Turns on the DC power supply once a second keyswitch on the remote control unit is turned on.
15.	48 V IN connector	Provides 48 V input power to the DDI. Protected by the fuse on the DC power supply.
16.	DC POWER SUPPLY connector	Connector for the 25 pin interconnection cable between the DC power supply and the DDI. This cable supplies control signals to turn on the DC supplies. Refer to Figure 6-7 for the system interconnection diagram. Refer to Table 6-5 for a list of signals in this cable.
17.	RF AMP connector	Connector for the 25 pin interconnection cable between the RF amplifier and the DDI. This cable supplies control signals from the DDI and supplies status information from the RF amplifier Refer to Figure 6-7 for the system interconnection diagram. Refer to Table 6-6 for a list of signals in this cable.
18.	INPUT/OUTPUT connector	Connector for the 37 pin interconnection cable between the remote control unit and the DDI. This cable supplies control signals from the remote control unit and supplies status information from the DDI. Refer to Figure 6-7 for the system interconnection diagram. Refer to Table A-4 for a list of signals that travel through this cable and the method to control the system without a remote control unit.
19.	HEAD connector	Connector for DB25 interconnection cable between the laser head and the DDI. This cable supplies control signals to the laser head and supplies status information fro the head. Refer to Figure 6-7 for the system interconnection diagram. Refer to Table 4-10 for a list of signals in this cable.
20.	USER connector	Allows connection of a customer furnished external interlock that will automatically shut down the laser when opened and allow laser operation when closed. If the plug is removed the system will not operate. The plug is shipped with connections between pins 3 and 6, 4 and 8, and also 5 and 9. Use pins 4 and 8 for connection to an external safety interlock contact closure. The system is shipped with a plug installed for operation with a remote control unit.



1. Power cable
2. Voltage select jumper
3. 4-pin connector
4. +48 VDC output (red wires)
5. Fuse
6. Return 48 VDC (black wires)
7. Control cable connector
8. On/off indicators
9. Cooling air exhaust
10. Line filter

Figure 6-13. DC Power Supply Option Indicators and Connectors

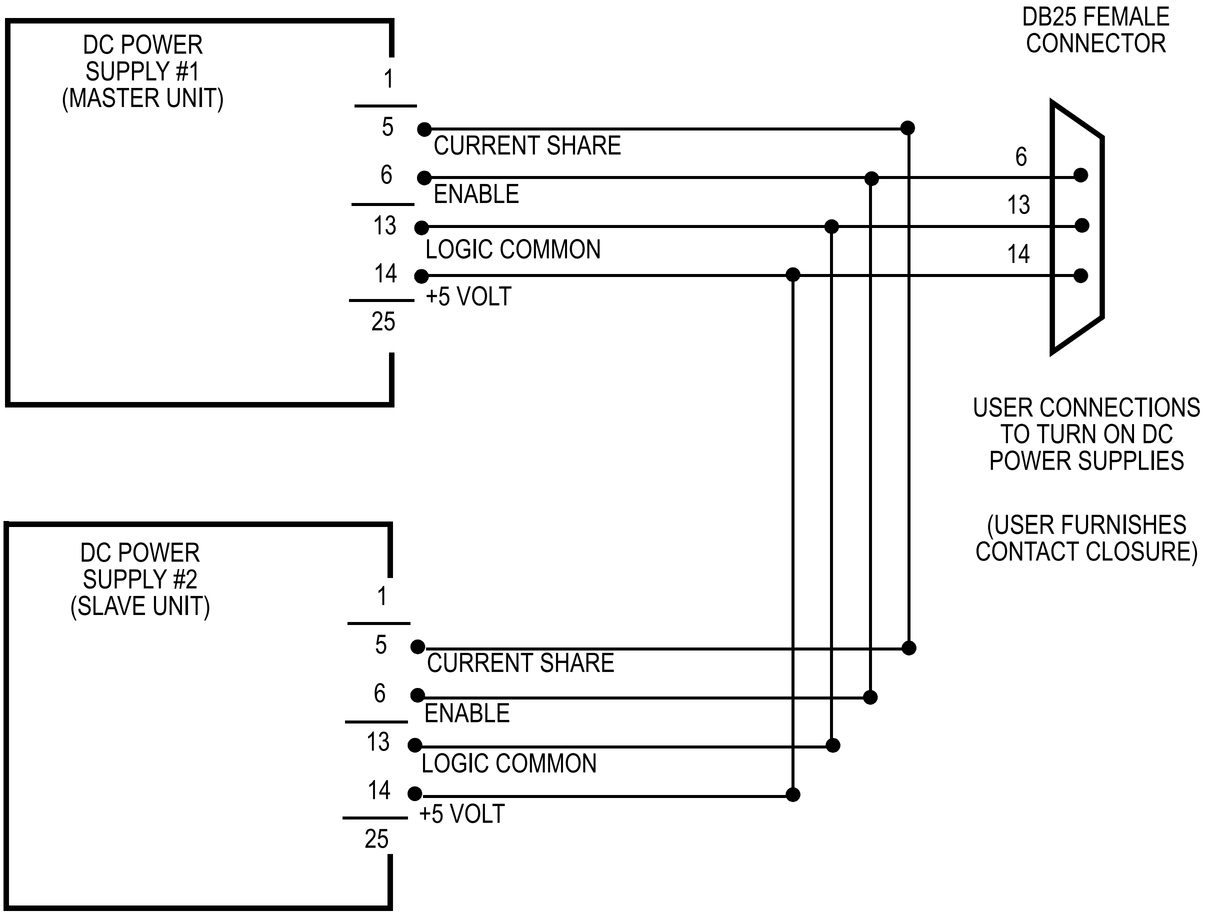
Table 6-4. DC Power Supply Option Indicator and Connectors

ITEM	CONTROL	FUNCTION
1.	Power cable	A 4-wire line cord that connects to a facility power outlet. The Diamond laser can operate on 208 ±10% VAC or 380 ±10% VAC 3Ø power with a ground. Refer to Chapter Three, Utility Requirements for additional information on connecting the optional DC power supply to facility power.
2.	Voltage select jumper	Orientation of this jumper selects input line voltage. Window in the jumper displays selected voltage. Both windows must select the same input voltage. ⚠ **Unit must be disconnected from AC power source while changing jumpers.**
3.	4-pin connector	4-pin connector for 48 VDC power to DDI and remote control unit.
4.	+48 VDC output (Red wire)	Provides a +48 VDC output. Output current from the DC power supply is 84 Amps. Connect to RF amplifier at lug labelled FROM DC SUPPLY +. Maximum length of these leads is 18 inches (46 cm).
5.	Fuse	3-Amp Slo Blow fuse for current to DDI and remote control unit.
6.	Return 48 VDC (Black wire)	48 V return. Connect to lug labeled FROM DC SUPPLY (–) on the RF amplifier. Maximum length of these leads is 18 inches (46 cm).
7.	Control cable connector	Provides for control and monitoring of the DC power supply using a DB25 connector. Refer to Table 6-5 for a list of signals.
8.	On/off indicators	Provides a visible on/off status. Lights green when the DC power supply is enabled and 48 V is available. There is an indicator on each supply.
9.	Cooling air exhaust	Provides cooling air for the DC power supply. No other cooling is required. Cooling fans must not be obstructed in installation. Inlet is at rear of DC supply
10.	Line filter	Line filter used to minimize electrical interference. The line cord is attached to line terminals labeled A, B, C, and GROUND on rear side.

DC Power Supply Control Connections

There is a DB25 pin connector on both the DC power supplies with a interconnecting cable assembly. One of the DC supplies operates as the master unit and the other is a slave unit connection. The function of the various terminals of the 25 pin connector is shown in Table 6-5. Note that only the functions shown in the schematic Figure 6-14 are used.

Connecting the REMOTE ENABLE (pin 6) and +5 V LOGIC (pin 14) in the 25 pin cable assembly will cause both DC power supplies to turn on. These leads can be tied into the main interlock circuit of the end users system. Note that if an over-current or over-voltage situation occurs, the DC supplied must have the AC input power turned off and then back on to reset the DC supply and also reset the +5 V logic voltage.



DC POWER SUPPLY #1 (MASTER UNIT)
1
5
CURRENT SHARE
6
ENABLE
13
LOGIC COMMON
14
+5 VOLT
25
DB25 FEMALE CONNECTOR
6
13
14
USER CONNECTIONS TO TURN ON DC POWER SUPPLIES
(USER FURNISHES CONTACT CLOSURE)
DC POWER SUPPLY #2 (SLAVE UNIT)
1
5
CURRENT SHARE
6
ENABLE
13
LOGIC COMMON
14
+5 VOLT
25

Figure 6-14. DC Power Supply Control Interconnection

Table 6-5. DC Power Supply DB25 Connector Pinouts

PIN NUMBER	FUNCTION	DESCRIPTION
1	+V sense	Provides for local or remote voltage sensing.
2	–V sense	Provides for local or remote voltage sensing.
3	+ margin reference	Provides for a 5% increase in output voltage.
4	V1 Margin	Used in conjunction with pin 3 or 4 for +5% or –5% margin.
5	Current share	Provides for current sharing when using dual units.
6	Remote enable	DC power supply enable signal. Connecting +5 V from pin 14 enables the DC power supply. No connection disables the power supply.
7	No connection	
8	No connection	
9	No connection	
10	No connection	
11	Current monitor	Analog output proportional to output current. 5.0 Volts full scale. Linear over 10 to 100% load.
12	Current monitor return	Reference for pin 11 output.
13	Logic common	Logic power common for pin 14.
14	+5 V logic	5 V, 50 milliamp source for external use. Referenced to logic common, pin 13. This voltage turns on when AC power is applied to the DC power supply.
15	No connection	
16	No connection	
17	No connection	
18	No connection	
Pins 19 through 25 are not used.		

Table 6-6. RF Amplifier DB25 Connector Pinouts

PIN NUMBERS	FUNCTION	DESCRIPTION
1	ANALOG FORWARD power	Analog output signal representing forward voltage from the RF amplifier to the laser head. +5 V full scale.
2	ANALOG REFLECTED power	Analog output signal representing reflected voltage from the tube. +5 V full scale.
3	ENABLE	Connecting this pin to return enables the RF amplifier. This pin can also be used for external safety interlock.
4, 5, 6	— —	Not currently used on Diamond.
7 (+) and 20 (–)	MODULATION - input signal	Differential input signal that controls the laser output. Laser output power will be present for the duration of this pulse only. Pulse widths should be in the range of 10 to 999 µsec at <50% duty cycle.
8 (+) and 21 (–)	DIGITAL REFLECTED power - output signal	Differential signal that does not change state when the RF amplifier is modulated on. If this signal does change state, this indicates a failed laser tube, RF cable, or RF connector.
9 (+) and 22 (–)	DIGITAL FORWARD power - output signal	Differential signal that changes state when the RF amplifier is modulated on. Under a failed condition of the RF amplifier, this signal will not change states.
10 (+) and 23 (–)	DUTY CYCLE LIMIT - output signal	Differential signal that does not change state unless the modulation pulse is on for more than a 50% duty cycle or a modulation pulse width longer than 1 ms.
11 (+) and 24 (–)	VSWR LIMIT - output signal	Differential signal that does not change under normal operating conditions. It will turn on if there is a tube fault that causes an excessive mismatch between the laser tube and the RF amplifier.
12, 13	— —	Not currently used on Diamond.
14, 15, 16	RETURN	Reference for pin 1, 2, and 3
17, 18, 19, 25	— —	Not currently used on Diamond.

OPERATOR'S MANUAL

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APPENDIX A
EXTERNAL DIAMOND CONTROL

COHERENT

Direct Control of Diamond System

The Diamond K-300 Performance Package system can be controlled directly by a computer or similar device connected to the DB37 plug labelled CONTROLLER on the Diamond power module.

The Diamond K-300 Basic system can be controlled directly by a computer or similar device connected to the DB37 plug labelled J1 INPUT/OUTPUT on the Diamond Digital Interface.

This allows completely independent control and monitoring of the laser by a computer.

Data between the processor and the Interface is performed over an 8 bit I/O. The Diamond Digital Interface traps warning and fault conditions, provides an interlock, ground loop isolation, and allows status and faults to be read.

This interface is designed to ease the connection to the laser system and to provide hardware handling of faults and interlocks for microprocessor based systems. The operation of the laser system is expected to be checked by software from the microprocessor thereby adding redundancy to the system.

The Basic Configuration

Figure A-1 shows the simplest way to connect your controller to the laser system. The controller communicates with the Diamond Digital Interface through the 14 signal lines as shown in Figure A-1. Each of the signal lines has a separate return, so it uses 28 wires. Also, pull-up resistors are needed on the 6 output signal lines going from the Interface to the Controller as shown in Figure A-1. Additionally, there are two pairs of lines that can be used in the interlocks to the controller at the option of the user.

The term “assert” is used to indicate that when positive-true logic is examined the level is high, and when negative-true logic is examined the asserted level is low. All input optocouplers are asserted when turned on. (The corresponding function is turned on when the optocoupler is turned on.)

Input Description and Timing Considerations

All inputs are optically isolated. Most inputs use a slow optocoupler that limits its response time to about 500 µs. The input functions are described in Table A-2 and the pin locations are found in Table A-4.

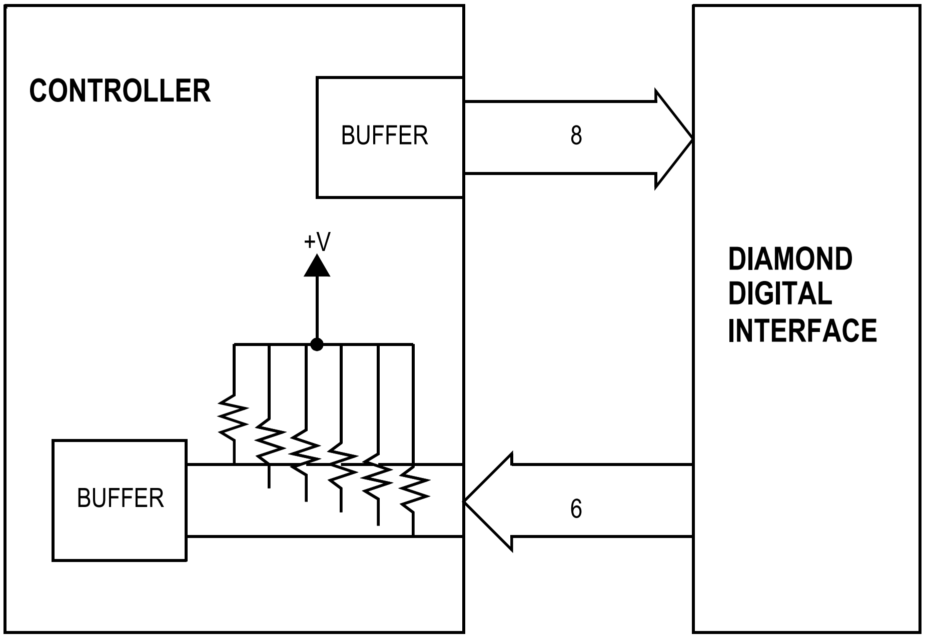


Figure A-1. Basic Configuration

Input Drive Recommendation

The slow inputs use CNY-17-2 optocouplers. The exception is the RFD signal which uses a fast 6N137. The CNY-17-2 optocouplers have 715 Ohm series resistors to limit the drive current to 5 mA when using the suggested configuration shown in Figure A-2. The 6N137 device has two resistors and requires 12 mA of drive current. Interfacing other logic families is possible provided the proper current drive is sent through the optocoupler and at least 1.4 Volts is applied across the device.

The recommended device to drive the optical isolators is a MC74HCT240A. Each of the eight outputs produces a high level of 4.0 Volts that can sink 12 mA.

Output Description and Timing Considerations

There are six output signals summarized in Table A-1. Four outputs are multiplexed to indicate the status of the system including faults and warnings. These four outputs are described in Table A-1 and the pin locations are shown in Table A-4. Note that the three fault conditions WATER FLOW, HEAD THERMAL, and HEAD COVER will not allow the laser to operate. See the discussing on Recovering from a Fault later in this section.

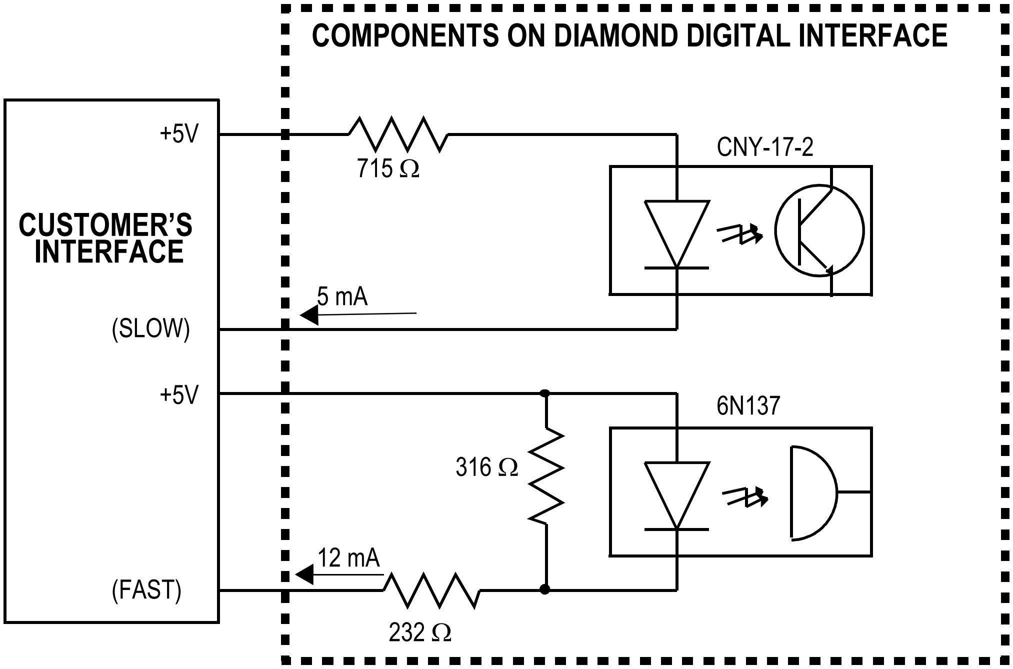


Figure A-2. Suggested Input Configuration

Table A-1. Output Description

OUTPUT SIGNAL NAMES	OUTPUT SIGNAL FUNCTIONS	DESCRIPTION
SHUTTER_SENSE	Sense shutter position as open, closed, or in between.	This has three states: open (asserted), closed (not asserted), in-between open and closed (pulsing). The pulsing rate is determined by the system water flow. When the shutter is commanded to close from the open state, typically 1 1/2 pulses will be sensed on this signal line. The water flow rate could be determined from the pulse width.
ALERT	Signal any warnings or faults occurred.	This output is asserted after any warning or fault is trapped by the hardware. If more than one warning or fault occurs, this output will not differentiate the added warning or fault; it will remain at the asserted level. This output can be cleared by the CLR_FLT command, but only after the warnings or faults are corrected.
OUT0 - OUT3	Multiplexed nibbles.	There are 4 sets of nibbles (4 bits), that allow 16-bits of data to pass to you. OUT0, OUT1, OUT2,and OUT3 output lines can represent faults, warnings, or status information depending of the code at input lines A and B.

Table A-2. Input Signals

INPUT SIGNAL NAMES	INPUT SIGNAL FUNCTION	INPUT SIGNAL TIMING AND OTHER CONSIDERATIONS
SHUTTER_CMD	Shutter open or closed.	Allow 200 ms to open the shutter, and 1.5 seconds to close it. Debounce this input on your side of the interface. This is a level sensitive input.
AIM	Aiming beam on or off.	Propagation delay time is about 500 µs to turn on (or off) the aiming beam. No debouncing is required. This is a level sensitive input.
RFD	RF Drive pulses for laser power.	The 6N137 optocoupler used on this input responses well above 100 KHz. Pulses are limited by the RF-AMP not the Diamond Digital Interface. Check the RF-AMP specifications for rate limitations.
RF_ENC	Drive pulse ENable Command.	The Interface responds within 500 µs to this command. The Diamond Digital Interface logic will override this command if a fault condition occurs. The logic will then disable drive pulses and this command will be ignored until the fault is corrected and cleared. (The ILK_OK status bit is the signal that indicates faults trapped by the logic. ILK_OK must be asserted to allow you control of this input. See the section called "Description of status bits" in this Specification for more detail.) This input responds to an asserted edge after a fault is cleared or after 48 V power is first turned on. Afterwards, this input is level sensitive. Debounce this input at your side of the interface.
PWR_H, PWR_L	Turning on or off the DC supply	This is a level sensitive command that is left asserted while the laser is in normal operation. This command, interlocks, and the key switch are in series and must all be asserted before the +48 Volts is turned on. Assuming the system turns on with this command, the interface will initialize itself in about 7 seconds. (Your diagnostics might be done during the wait). No debouncing is required.
CLR_FLT	Clear warnings and faults.	This is a level sensitive command where the Diamond Digital Interface converts the asserted level from you into a pulse to clear warnings and faults. This input must be asserted for at least 2 µs which causes only one clear pulse to be generated inside of the Interface. In order to clear it again you must deassert this input for at least 2 µs and then reassert it again. While the Interface is clearing warnings and faults, the enable to the RF amp will be blocked. For redundancy, make certain your drive pulses are shut off before using this command.
A,B	Select multiplexer 4-bit value as read on the opposite side of the optocouplers from you.	Allow 500 µs after changing the code on these lines before reading the new multiplexer value you have selected. When both input optocouplers are not asserted A=1, and B=1; the status nibble can be read (a nibble is 4 bits), which is how your system should normally be used. Only after you detect a problem, by sensing the *ALERT* output line, should you need to change the code on *A, B* in order to read faults or warnings. Output faults and warnings when asserted cause output optocouplers to turn off. For example, suppose only a WATER_FLOW fault occurred, then with A=0, B=1, the output optocoupler at OUT0 will be off, and output optocouplers at OUT1 to OUT3 would be conducting.

The SHUTTER SENSE output indicates the status of the shutter. It is asserted when the shutter is open and will cycle on and off when the shutter is not in the selected position. This latter condition is also indicated as a shutter warning on the multiplexed outputs. The final output is ALERT which is asserted when a fault or warning exits.

Output Drive Recommendation

The optocoupler collector outputs are designed to sink 1.6 mA in addition to a 10 K Ohm pull-up resistor to +5 V (±5%); that is to interface to one TTL input (or 4 LS-TTL inputs). As an example, see Figure A-1 using the pull-up resistor technique used on the input optocouplers. Since you may want to interface to another logic family, pull-up resistors were not included on the Diamond Digital Interface for the output optocouplers.

Description of the Faults and Warnings

All faults and warnings are latched by the hardware on the Diamond Digital Interface. Faults inhibit laser modulation and thus prevent any laser output power. Warnings do not inhibit laser modulation.

Fault and warnings are also indicated on the front panel of the power module or the DDI with indicators. A complete description of the faults and warnings is located in Chapter Four, Daily Operation.

Table A-3. Diamond Digital Interface Multiplexer

SELECT LINES			**MULTIPLEXER RETURN VALUE (OUT0 - OUT3)**			
(See Note below)	**A**	**B**	**OUT0**	**OUT1**	**OUT2**	**OUT3**
FL0-FL3	0	0	FL0, DUTY CYCLE	FL1, VSWR	FL2, FORWARD	FL3, REFLECTED
FL4-FL7	0	1	FL4, WATER FLOW	FL5, COVER	FL6, THERMAL	IL7, SHUTTER FAULT
Spare	1	0	not used	not used	not used	not used
Status	1	1	ENB	READY	RF_GATE	ILK_OK
Note: A=1 when the corresponding input optocoupler is not asserted (when the optocoupler is off), and likewise for B.						

Table A-4. Power Module **CONTROLLER** *Connector (INPUT/ OUTPUT on DDI)*

PIN NUMBER	TYPE	DESCRIPTION
1	output	OUT3 reference pin, connect to your common ground
2	output	OUT3 signal pin, pull up with 10 K Ohm to +5 V
3	output	SHUTTER_SENSE reference pin, connect to your common
4	output	SHUTTER_SENSE signal pin, pull up with 10 K Ohm to +5 V
5	output	ALERT reference pin, connect to your common
6	output	ALERT signal pin, pull up with 10 K Ohm to +5 V
7		not used
8	input	SHUTTER_CMD drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA, debounce
9	input	SHUTTER_CMD supply pin, connect to +5 V (±5%)
10	input	"A" drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA, debounce
11	input	"A" supply pin, connect to +5 V (±5%)
12	input	"B" drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA, debounce
13	input	"B" supply pin, connect to +5 V (±5%)
14	input	AIM drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA
15	input	AIM supply pin, connect to +5 V (±5%)
16	input	CLR_FLT drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA, debounce
17	input	CLR_FLT supply pin, connect to +5 V (±5%)
18	input	RF_ENC drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA, debounce
19	input	RF_ENC supply pin, connect to +5 V (±5%)
20	output	OUT2 signal pin, pull up with 10 K Ohm to +5 V
21	output	OUT2 reference pin, connect to your common
22		reserved for future use
23		reserved for future use
24	output	OUT1 signal pin, pull up with 10 K Ohm to +5 V
25	output	OUT1 reference pin, connect to your common
26	output	OUT0 signal pin, pull up with 10 K Ohm to +5 V

Table A-4. Power Module CONTROLLER *Connector (INPUT/ OUTPUT on DDI) (Continued)*

PIN NUMBER	TYPE	DESCRIPTION
27	output	OUT0 reference pin, connect to your common
28		not used
29		not used
30	user	connects to J7 pin 6
31	user	connects to J7 pin 7
32	user	connects to J7 pin 5
33	user	connects to J7 pin 4
34	input	RFD drive pin, pull low (≤ 0.4 V), sink 12 mA to 17 mA
35	input	RFD supply pin, connect to +5 V (±5%)
36	input	PWR drive pin, pull low (≤ 0.4 V), sink 5 mA to 30 mA
37	input	PWR supply pin, connect to +5 V (±5%)

Table A-5. Power Module INTERLOCK *Connector (*USER *on DDI)*

PIN NUMBER	TYPE	DESCRIPTION
1		DC supply margin +
2		DC Supply margin return
3	--------	+5 VL return (keep isolated from your ground)
4	user	connects to J1 pin 33
5	user	connects to J1 pin 32
6	user	connects to J1 pin 30
7	user	connects to J1 pin 31
8	interlock	+5 VL series main interlock to key switch. Connect to pin 9 if external interlock is not used. (If you use an external interlock, the +48 V supply will not operate without this line looping to pin 9 through your external interlock.)
9	interlock	+5 VL series main interlock from laser head cable. This line carries +5 volts which is always present while the +48 V DC supply is plugged into the AC line, and while the laser head cable is attached between the Diamond Digital Interface and the Head.

Description of Status Bits

There are four status bits. They are read through OUT0-OUT3 output lines when A, and B optocouplers are turned off, which makes both lines A and B high.

The system state for normal operation is for RF_GATE, READY, and ILK_OK to be asserted.

- ENB when asserted enables the RF-amp. This status bit is taken on the Diamond Digital Interface just before the hardware that drives the RF-amp's enable input. (It's modified by CLR_FLT, RF_GATE, and READY).
- READY when asserted signifies that the 8 second delay has passed.
- RF_GATE is asserted when interlocks are OK (ILK_OK) followed by the RF_ENC command making a transition to its asserted level.
- ILK_OK when asserted indicates no faults occurred, but warnings may exist.

Software Redundancy Checking

The following items are suggested as redundancy checks to the laser system. These checks will verify proper operation of the Interface Electronics and can be performed by your software.

When preventing laser emission, stop your RFD signal, disable RF_ENC, and close the shutter. Next, read the status bit called ENB to make sure the Interface has commanded the RF amp to shut off.

The shutter can be checked for proper operation by cycling it on then off before you command laser light. Since it takes about 1.7 seconds to cycle the shutter, this check could be done during the 8 second initialization time that occurs when the +48 Volts is first turned on. Additionally, it is advisable for you to check the shutter position each time you open or close it to ensure at the shutter position has changed when you command it to do so.

Hardware Changes Required for External Control

Two changes must be made to the connections to the interlock network for the system to be operational with an external controller. The first item that must be changed is the plug in the DB9 connector labeled INTERLOCK on the power module or USER on the DDI. For the system to be operational only pins 8 and 9 should be connected together in the plug.

The second change that is required is to remove the four pin cable located at the connector labeled 48 V on the front panel of the power module. This must be replaced with a plug where the only connection is between pins 2 and 3. In the case of a Diamond Basic System, this plug must replace the connection at the DC power supply to the remote control unit.

These two connectors are available from your Coherent sales representative. The part number required is 0165-723-00.

Normal Power Up Sequence

1. Switch all inputs to the DDI to the not asserted condition.
2. Turn on the DDI key switch.
3. Assert the PWR signal. This is accomplished by switching pin 36 to a TTL low and pin 37 a TTL high.
4. Monitor the ILK_OK status line at OUT3. Wait until it is asserted and if it is not asserted in about 10 seconds, then check the faults.
5. Toggle the RF_ENC line from off to on then back to off. The transition from not asserted to asserted must occur before the DDI will start the next sequence. By commanding it off again, this ensures that there will be no laser output until desired. Both RF_ENC and RFD must be asserted for their to be laser output.
6. Monitor the READY status line at OUT1. A delay of 8 seconds occurs before the READY line is asserted following toggling the RF_ENC line at power up. This delay period is indicated by the flashing amber indicator labelled DELAY on the front panel of the DDI. If this signal is not asserted then check the faults.
7. The shutter operation can be verified by opening the shutter and waiting about 5 seconds and closing the shutter. Use the SHUTTER_CMD to open and close the shutter and monitor the operation at SHUTTER_SENSE output.
8. Turn on the aiming beam as required by asserting AIM.

Normal Operation

1. When it is desired to have the laser system in a ready condition, assert RF_ENC.
2. Use the RFD command to modulate the laser on and off at the desired pulse width and pulse period. This signal should be used to modulate the laser at the desired operating point since it is faster than the RF_ENC command. See the Operator's Manual for limiting values of the pulse width and pulse period.

3. During operation monitor the ALERT output. When the ALERT is asserted then cycle the A and B inputs to determine the specific fault or warning as indicated by the signals at OUT0 through OUT3.
4. When the operation is complete and the laser needs to be in a standby mode, bring the RF_ENC command to the not asserted condition.

Recovering From a Fault

1. If a fault condition is determined, bring the RF_ENC and RFD commands to the not asserted condition.
2. After the fault condition is cleared, toggle the CLR_FLT command from not asserted to asserted and then back to the not asserted condition.
3. Perform the power up sequence starting at step 4 and continuing to at least step 6. If there are no indicated faults then the system is ready for normal operation.

Note that the fault conditions will stop laser operation and these fault conditions are: water flow, laser head cover, and shutter over temperature (noted as thermal) The warnings will not stop laser operation but in some cases laser power will appear unstable if the duty cycle limit or the VSWR warnings have occurred.

Applications

Some Features of the Diamond Digital Interface

- Since you have direct creation of the drive pulses, you can create special pulse widths to customize your particular cutting needs for example shaping entry and exit holes.
- All warnings and faults are trapped for you and are available through the INPUT/OUTPUT cable. Faults that can damage the system shut the system off independent of the controller, such as low water flow.
- A convenient alert indicator simplifies interrupt driven software since it becomes active only when a fault or warning exists.
- Data between the processor and the Interface travels over an 8 bit I/O through one connector simplifying hardware needs.

- Input and output optocouplers on all input and output lines separate ground loops and allow for mixed logic families to drive and receive signals.
- A key switch mounted at the Interface provides shut down of the system independent of the controller. So if someone accidentally commanded the laser to turn on at the controller site, the key switch at the Interface site could be used to prevent the laser system from turning on.
- To accommodate special needs of our customers, four extra signal wires pass from the back of the Interface straight through to your controller via the INPUT/ OUTPUT cable.

Interlock or USER Connector Features

- Access is provided to the external interlock that shuts off the +48 Volts to the laser system.
- Four “user” type pins are provided where signals can travel back and forth along the Input/Output cable that joins the Interface to the controller. For example, if you wanted to sense the relay closure at your controller, you could use 2 of the 4 pins to pass that signal. This feature allows you to send any low power signal from the location of the Diamond Digital Interface to where you have the controller. (The Coherent controller uses these pins and therefore they are not available when using it.)

Troubleshooting

Table A-6. Troubleshooting

SYMPTOM	CHECK
No CO2 laser light.	ENB status bit to check if the RF-amp is enabled. Check your RF drive pulses. Check if the shutter is open.
Laser system’s +48Volts doesn't turn on.	The +48V cable is connected. The Head cable is connected. The key switch is turned on. Your external interlock is closed. You have sent the PWR command.
RF_GATE is not asserted.	That the ILK_OK bit was asserted before the RF_ENC command made a transition to its asserted level.

OPERATOR'S MANUAL

APPENDIX B
DIAMOND K-225i

COHERENT

This appendix details the specifications of the Diamond K-225i laser operating at 9.4 µm wavelength. Beyond this primary difference and the resulting change in the specified output power of 225 W, there are very little differences to the Diamond K-300. Coherent has developed this laser to meet the needs of the material processing applications that have better material interaction than the standard Diamond K-300 laser. The following tables shows the output specification while all the utility requirements are the same as the Diamond K-300 as presented in Table 1-3 and Table 3-3.

Note that the pulse rise and fall time is faster for the K-225i than for the K-300. In some applications especially involving high line or surface speeds this could be an important improvement in performance.

The only difference in the product labeling is the label on the front of the laser head which specifies the laser wavelength. The power and wavelength safety label that is shown a in Figure 2-1 is changed and shown below.

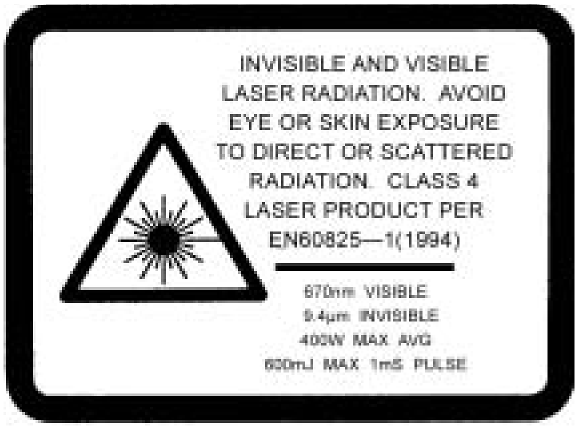
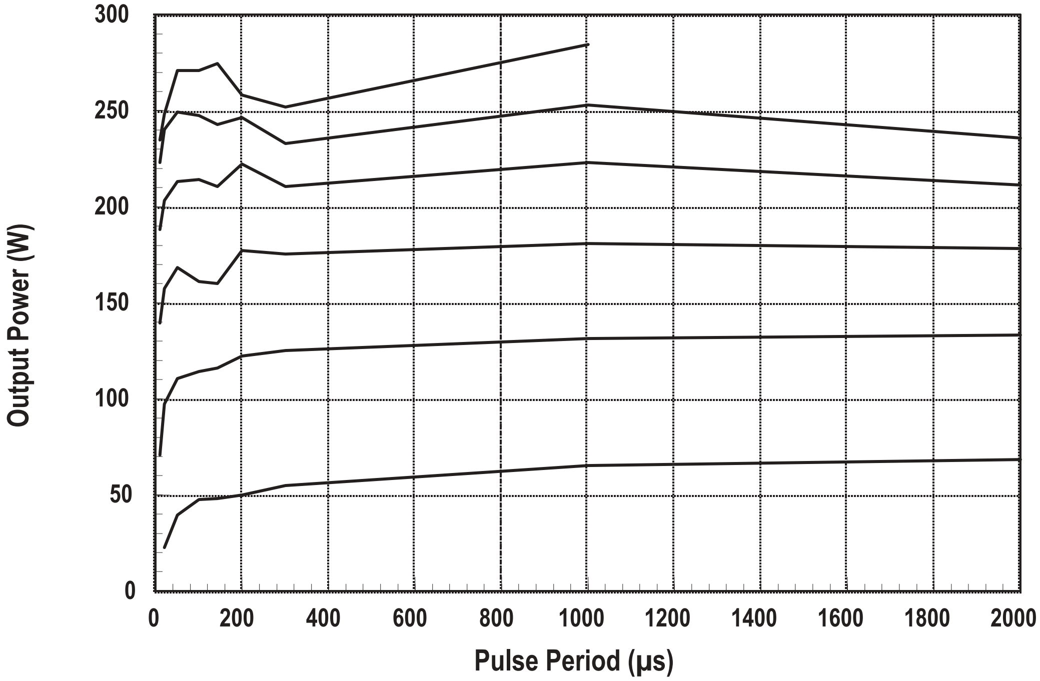
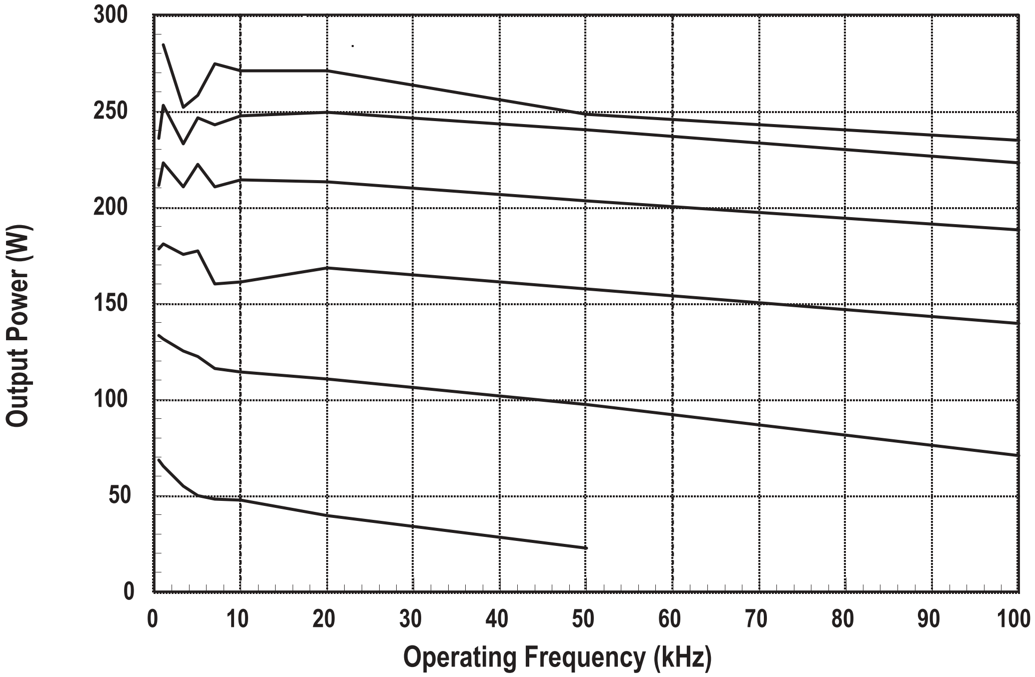


Figure B-1. Location of Safety Labels

The laser output power performance with pulse period and pulse width are shown below. See Chapter Four for details of operating the Diamond laser system.



A. Shorter pulse periods (higher frequency range) — 100 to 1000 µs



B. Longer pulse periods (lower frequency range) — 1000 to 10,000 µs

Note: Each curve represents the pulse period.

Figure B-2. Typical Diamond K-225i Laser Output Power

Table B-1. K-225i Specifications

PARAMETER	SPECIFICATION
GUARANTEED PERFORMANCE	
Average output power (1)	225 watts
M2—transverse mode quality	<1.3
Power range(1)	10 to 225 watts
Pulse frequency range	0 - 100 kHz
System life time (2)	1 year
TYPICAL PERFORMANCE	
Peak effective power	200 to 650 watts
Optical pulse rise time	< 25 µs
Optical pulse fall time	< 40 µs
Pulse energy range	10 to 450 mJ
Pulse period (minimum)	10 µs
Modulation pulse width range	2 to 1000 µs
Output power stability (3)	< ± 8%
Beam waist diameter ($1/e^2$)	6.8 ± 1.0 mm (0.27 ± 0.04 in)
Beam divergence (full angle)	2.1 ± 0.3 mrad
Beam pointing stability(4)	< 200 µrad
Beam ellipticity	< 1.2 : 1
Beam polarization (parallel to baseplate)	Linear > 100 : 1
Wavelength	9.4 ± 0.2 µm
Tube shelf life	> 1 year

The above specifications subject to change without notice

(1) Guaranteed at 600 µs pulse width at 60% duty cycle with the inlet cooling water temperature at 25°C. Allow a 1%/°C power derating for inlet cooling water temperature to a temperature of 35°C.

(2) See Appendix D for the full system warranty.

(3) Measured as ±(Pmax – Pmin)/2Pmax from a cold start at 25°C for the output power range for pulse width ≥ 2 µs.

(4) Full angle within a ± 5°C inlet cooling water temperature range.

APPENDIX C: PARTS LIST

The following parts can be ordered by contacting Coherent Customer Service at 1-800-367-7890 (within USA) or 1-408-764-4557 (outside USA) or your local Coherent representative.

Table C-1. K-300 and K-225i Performance Package Parts List

DESCRIPTION	PART NUMBER	
Laser head		
K-300	1047101	
K-225i (9.4 µm)	0174-587-00	
Head board	0169-757-00	
Shutter assembly (includes aiming laser)	0170-111-51	
Water flow switch:		
Impeller	0164-441-00	
PC Board	0164-080-50	
Lens, laser emission indicator	3902-0064	
Emission bulbs	3901-0169	
Water screen kit (for laser head)	0165-551-00	
Remote control unit	0174-567-00	
1 Amp Slo Blo fuse	5110-0055	
RF cable - Power module to laser head		
Standard RF cable	10 ft. (3 m)	0165-769-10
Flexible RF cable	20 ft. (6 m)	0165-769-20
Flexible RF cable	30 ft. (9 m)	0165-769-30
Flexible RF cable	40 ft. (12 m)	0165-769-40
Flexible RF cable	50 ft. (15 m)	0165-769-50
Laser Head Control Cable-25 pin		
Standard Cable	10 feet length	0168-666-10
Optional	20 feet length	0168-666-20
Optional	30 feet length	0168-666-30
Controller Cable-DB37		
Standard Cable	8 feet length (2.4 m)	0168-667-00

Table C-1. K-300 and K-225i Performance Package Parts List (Continued)

DESCRIPTION	PART NUMBER	
Power module	0174-569-00	
3 Amps Slo Blo fuse	5110-0086	
48 V Cable assembly (4 pin) Standard Cable	10 feet (3 m)	0164-289-10
Water lines: 3/8" ID (specify length required) 1/2" ID (specify length required)	 2521-0030 2521-0032	
Water filter	0124-189-00	
Water filter cartridge	2603-0016	
Maintenance kit—end user	0174-613-00	
External controller kit	0165-723-00	
Laser purge filter kit (option)	0174-849-00	
Replacement DX filter element	2603-0152	
Replacement BX filter element	2603-0153	
Additional Teflon tubing (specify length required) (10.5 µm)	2521-0210	
Feedback isolator (10.5 µm)	5701-0060	
Feedback isolator (9.4 µm)		
Cut quality enhance (circular polarizer)	5701-0059	

Table C-2. K-300 Basic Parts List

DESCRIPTION	PART NUMBER
Laser head with electrical shutter	1047101
Head board	0169-757-00
Electrical shutter assembly (including aiming beam)	0170-111-51
Water flow switch: Impeller PC board	 0164-441-00 0164-080-50
Emission indicator bulbs	3901-0169
Water screen kit	0165-551-00

Table C-2. K-300 Basic Parts List (Continued)

DESCRIPTION	PART NUMBER	
Diamond digital interface	0164-410-50	
RF amplifier	0166-465-00	
Remote control unit	0174-567-00	
1 amp slo blo fuse (T1.0 A, 250 V)	5110-0055	
DC power supply	0166-182-00	
3 amp slo blo fuse	5110-0086	
RF cable — RF amplifier to laser head		
Flexible RF cable	10 feet (3 m)	0165-769-10
Flexible RF cable	20 feet (6 m)	0165-769-20
Flexible RF cable	30 feet (9 m)	0165-769-30
Flexible RF cable	40 feet (12 m)	0165-769-40
Flexible RF cable	50 feet (15 m)	0165-769-50
Laser head control cable — DB25		
Standard cable length	10 feet (3 m)	0168-666-10
Optional length	20 feet (6 m)	0168-666-20
Optional length	30 feet (9 m)	0168-666-30
Optional length	40 feet (12 m)	0168-666-40
Optional length	50 feet (15 m)	0168-666-50
Controller cable — DB37 between DDI and remote control unit		
Standard RF cable length	8 feet (2.4 m)	168-667-00
	10 feet (3 m)	168-667-10
	20 feet (6 m)	168-667-20
	30 feet (9 m)	168-667-30
	40 feet (12 m)	168-667-40
	50 feet (15 m)	168-667-50
48 VDC cable assembly (4 pin) — DB37 between DDI and remote control unit		
Standard RF cable length	10 feet (3 m)	0164-289-10
	20 feet (6 m)	0164-289-20
	30 feet (9 m)	0164-289-30
	40 feet (12 m)	0164-289-40
	50 feet (15 m)	0164-289-50
Water lines—3/8" ID (specify length required)	2521-0030	
Water filter	0124-189-00	

Table C-2. K-300 Basic Parts List (Continued)

DESCRIPTION	PART NUMBER
Water filter, cartridge	2603-0016
Water line, 1/2" ID (specify length required)	2521-0032
Maintenance kit—end user	0174-613-00
External controller kit	0165-723-00
Laser purge filter kit (option)	0174-849-00
Replacement DX filter element	2603-0152
Replacement BX filter element	2603-0153
Feedback isolator (10.5 µm)	5701-0060
Cut quality enhance (circular polarizer)	5701-0059

APPENDIX D: WARRANTY

Diamond Laser Warranty

Coherent, Inc. warrants to the original purchaser that the Diamond laser system conforms to the specifications published by Coherent and is free from defects in materials and workmanship.

For specific warranty terms and conditions for your Diamond laser system, refer to your sales contract.

Diamond Laser systems are warranted for parts and labor for a period of twelve (12) months. Warranty begins from the date of shipment.

Diamond Laser systems do not include installation in the purchase price.

Conditions of Warranty

For warranty service requiring the return of any product to Coherent, the product must be returned to a service facility designated by Coherent. The Buyer is responsible for all shipping charges, taxes and duties.

Parts replaced under warranty shall become the property of Coherent and must be returned to Coherent, Inc., Santa Clara, or to a facility designated by Coherent. All laser systems must be carefully packed in a suitable shipping container(s). Coherent does not assume responsibility for components broken in shipment due to improper packaging or handling. The Buyer will be obligated to issue a purchase order for the value of the replaced parts and Coherent will issue credit when the parts are received.

Responsibilities of the Buyer

Damage to the Diamond laser caused by failure of Buyer's utilities or the Buyer's failure to maintain an appropriate operating environment, is solely the responsibility of the Buyer and is specifically excluded from any warranty.

The Buyer is responsible for prompt notification to Coherent of any claims made under warranty. In no event will Coherent be responsible for warranty claims later than seven (7) days after the expiration of the warranty.

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

1. Components or accessories with separate warranties manufactured by companies other than Coherent.
2. Improper or inadequate maintenance by Buyer.
3. Buyer-supplied interfacing.
4. Operation outside the environmental specifications of the product.
5. Improper site preparation and maintenance.
6. Unauthorized modification or misuse.

Coherent assumes no responsibility for customer-supplied material.

Coherent considers RF and other cables that are repeatedly flexed or bent to be consumables. As such these items are not covered under warranty.

The obligations of Coherent are limited to repairing or replacing, without charge, equipment that proves to be defective during the warranty period. Replacement systems may contain reconditioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. This warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized in writing by Coherent.

GLOSSARY

%	Percent
1/e2	Beam diameter parameter = 0.13534
°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
µm	Micrometers = 10-6 meters
µrad	Microradians = 10-6 radians
µsec	Microseconds = 10-6 seconds
Ω	Ohms
AC	Alternating current
Amp	Amperes
BNC	Type of connector
CaCO3	Calcium carbonate
CCW	Counterclockwise
CDRH	Center for Devices and Radiological Health (U.S. Government)
CFR	Code of Federal Regulation
cm	Centimeters = 10-2 meters
CO2	Carbon dioxide
DC	Direct current
DVM	Digital voltmeter
FPT	Female pipe thread
FCC	Federal Communications Commission (U.S. Government)
gpm	Gallons per minute
hex	
Hz	Hertz or cycles per second (frequency) (= 1/pulse period)
kg	Kilograms = 103 grams
kHz	Kilohertz = 103 hertz
kPa	Kilopascals = 103 pascals
kV	Kilovolts = 103 volts
kW	Kilowatts = 103 watts
LED	Light emitting diode
mA	Milliamperes = 10-3 Amperes
mg	Milligrams = 10-3 grams
MHz	Megahertz = 106 Hz
mJ	Millijoules = 10-3 Joules
mm	Millimeters = 10-3 meters
mrad	Milliradians = 10-3 radians (angle)
ms	Milliseconds = 10-3 seconds
mW	Milliwatts = 10-3 Watts (power)

N2	Nitrogen
nm	Nanometers = 10-9 meters (wavelength)
Ø	Phase
psi	Pounds per square inch
RF	Radio frequency
RMS	Root mean square (effective value of a sinusoidal wave)
STD	Standard
TTL	Transistor-to-transistor logic
V	Volts
VAC	Volts alternating current
VDC	Volts direct current
VSWR	Voltage, standing wave ratio
W	Watts

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DIAMOND™ K-300 Operator's Manual, Performance Package & Basic Plus
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Coherent P/N: 1048128, Rev AA